Radiological Health Data and Reports

VOLUME 10, NUMBER 12

DECEMBER 1969

(Pages 535–590)

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭl'o
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'co
10^{-15}	femto	f	fĕm'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g=2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^3	nanocuries per square meter	2.59 nCi/mi^2
pCi	picocurie(s)	10^{-12} curie=2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 12, December 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of the Interior
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

CONTENTS

CONTENTS—continued

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

John C. Villforth
Director
Bureau of Radiological Health

Address correspondence to the Managing Editor, *Radiological Health Data and Reports*, Bureau of Radiological Health, 12720 Twinbrook Parkway, Rockville, Md. 20852.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
Environmental Control Administration • Bureau of Radiological Health

Reports

Offsite Radiological Surveillance for Project Gasbuggy June 1967-July 1968

John R. McBride and *Dixon Hill*[1]

Project Gasbuggy, an experiment to stimulate gas recovery by nuclear means, was conducted on December 10, 1967, as part of the Atomic Energy Commission's (AEC) Plowshare Program. The Public Health Service by Memorandum of Understanding with the AEC is responsible for a comprehensive offsite radiological safety program. The data obtained during this program have documented that no radioactivity was introduced into the environment as a result of the Project Gasbuggy detonation. Surveillance of the El Paso natural gas producing wells near the Gasbuggy experiment was conducted to insure that gas contaminated with radioactivity was not present.

On Sunday, December 10, 1967, at 12:30:00 mountain standard time (m.s.t.), at a location 55 air miles east of Farmington, N. Mex., a 26-kiloton thermonuclear explosive was detonated 4,240 feet below the surface of the Carson National Forest (figures 1 and 3). The event, Project Gasbuggy, was the first joint government-industry experiment in the U.S. Atomic Energy Commission's (AEC) Plowshare Program. The joint sponsors, in addition to the AEC, were the U.S. Department of the Interior (Bureau of Mines) and the El Paso Natural Gas Company.

The main objective of the experiment was to determine if nuclear explosions can increase the production rate and ultimate recovery of natural gas from low permeability gas formations. Some flow tests, as well as gas quality analyses, have been made of the Project Gasbuggy well by the project participants; however, until more extensive flow tests are made in 1969, conclusive information will not be available as to the degree of success of the experiment.

Factors affecting the safety of the project included: the depth of emplacement of the device, the proximity of an aquifer to the detonation, and the location of gas production wells with respect to ground zero. The device was placed at a depth of 4,240 feet in the Lewis Shale formation in the San Juan Basin. This depth is about 40 feet below the bottom of the gasbearing Pictured Cliffs formation (figure 2). At this depth, the device was considered to be overburied by safety standards in use at the Nevada Test Site. (A 26 kt device would be considered safely emplaced at NTS at a depth of approximately 1,200 feet.) The lowest water bearing formation is the Ojo Alamo sandstone which is located from 3,475 to 3,650 feet below the surface at the site. The nearest aquifer, therefore, is approximately 590 feet above the shot point. The site chosen for the project is on land leased by El Paso Natural Gas Company. The only wells in the area belong to them and the closest production well is 3,400 feet from ground zero. As a precaution, all producing wells within approximately a 5-mile radius of ground zero were physically separated from the gas-transmission system. In addition the AEC hypothesized all possible failure modes which could release radioactivity into the atmosphere, into ground water, or into the natural gas production system. Although these failure modes were considered highly unlikely, the AEC authorized a comprehensive radiological safety program for Project Gasbuggy.

[1] Mr. John R. McBride is deputy director and Mr. Dixon Hill was project engineer, Southwestern Radiological Health Laboratory, Las Vegas, Nev. During Project Gasbuggy, Mr. McBride was senior PHS official on the Project. Mr. Hill was project officer for Gasbuggy in charge of all offsite radiological safety activities.

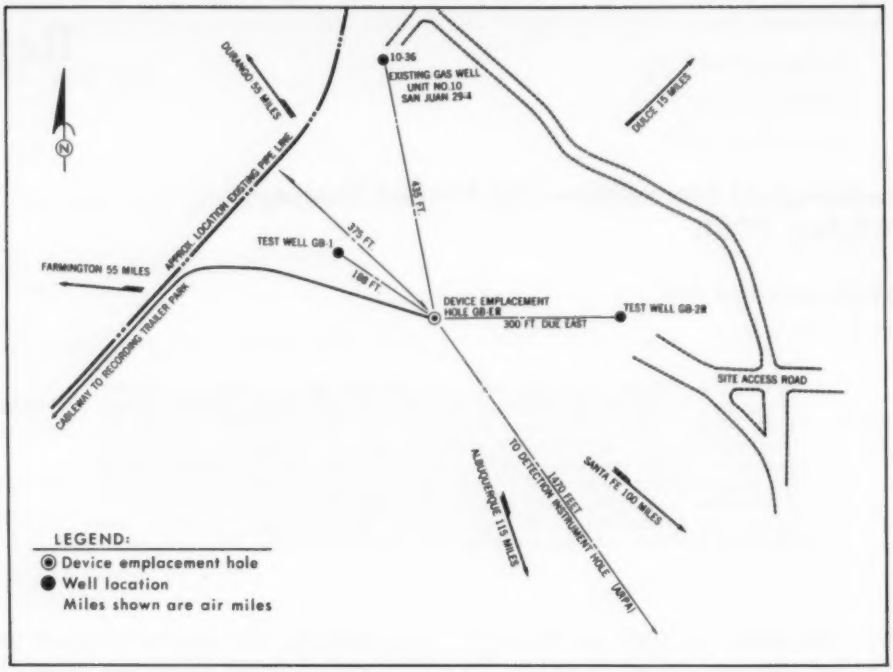

Figure 1. Project Gasbuggy emplacement hole and well locations

Offsite radiological safety program

This article summarizes the offsite radiological safety program for Project Gasbuggy as conducted by the Southwestern Radiological Health Laboratory (SWRHL) of the Bureau of Radiological Health. In accordance with a Memorandum of Understanding between the AEC and the Public Health Service, the SWRHL is responsible for conducting offsite radiological safety programs for all U. S. nuclear tests.

A surveillance program was established by SWRHL to collect and analyze environmental samples before and after the nuclear detonation in order to document any possible release of radioactivity to the offsite area and to be prepared to handle emergency procedures to insure protection of the public health in case an unforeseen accident occurred. Samples provided data on air, milk, water, natural gas, and external radiation levels in the area surrounding the site.

The offsite surveillance program was divided into three periods:

1. The preshot preparations—June 1, 1967, to detonation (1230 m.s.t. December 10, 1967);
2. The post-shot period, including the redrill of the emplacement hole (GB-ER)—December 10, 1967, to January 19, 1968;
3. The redrill of the Gasbuggy-2 (GB-2R, one of the two exploratory wells drilled before the emplacement hole) and subsequent natural gas flaring operations from GB-ER and GB-2R—June 13 to July 22, 1968.

Environmental samples were collected preshot to establish background radioactivity levels. Following the completion of the post-shot period and again after the GB-2R redrill period, samples were collected to form a comparison with the background data.

The SWRHL preshot preparations in the Project Gasbuggy area began in June 1967. During the summer of 1967, a census was taken of all people and milk cows within 100 miles of the Gasbuggy site; in addition, all mining and tunneling operations within 50 miles were located.

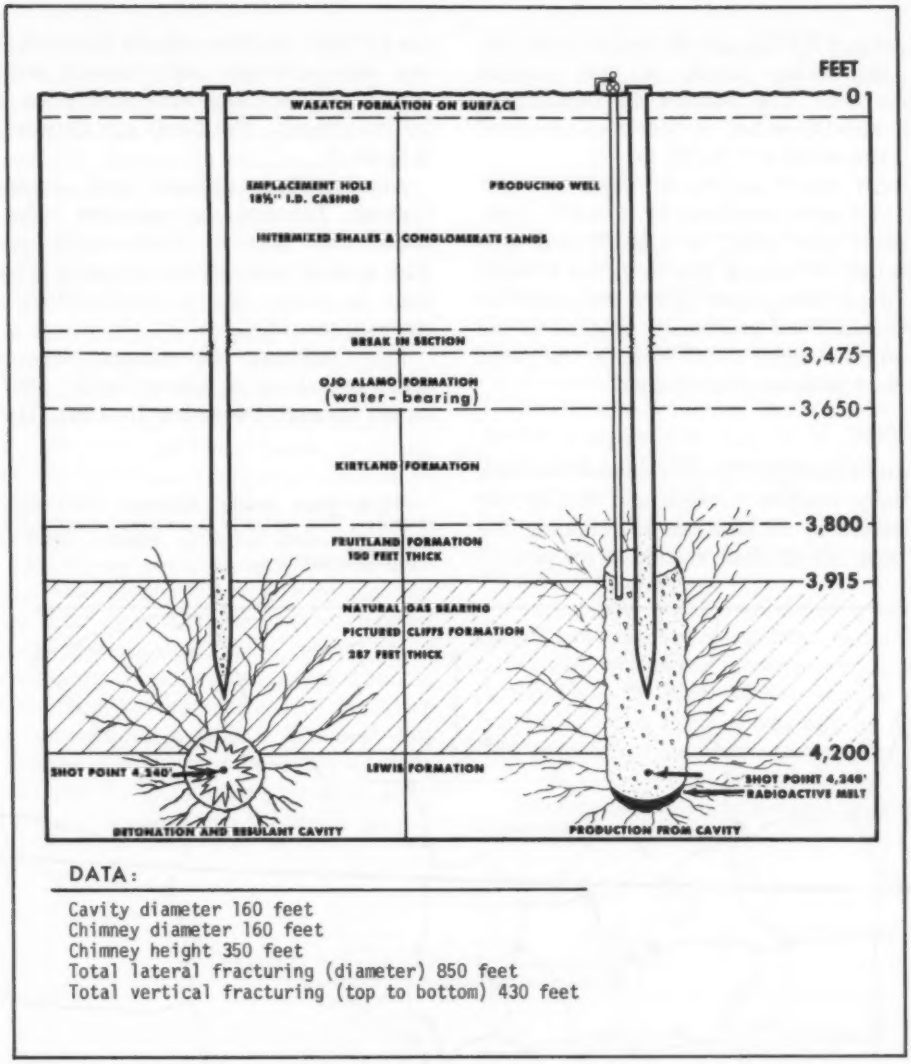

Figure 2. Project Gasbuggy predicted underground effects

As the census information was collected, personnel distributed printed information explaining the nature of the experiment and answered questions regarding their activities. The Community Relations Program was intensified during later periods when the SWRHL project officer and State health department officials visited local officials in surrounding communities. The initial environmental sampling was begun in August 1967. The dosimetry program began in October 1967. Medical and veterinarian activities began during the preshot period when the respective officers made visits to various State and local officials; these activities continued throughout the drillback of GB-ER. Approximately 30 people from the SWRHL and the health departments of New Mexico and Colorado were assigned to the SWRHL Gasbuggy surveillance program on December 1, 1967. A short training course was given to State personnel on procedures to be used and all personnel were oriented to the area around the site.

At shot time, SWRHL had 33 people on station, including monitoring teams in two aircraft circling the site. The number of people was reduced in mid-December to five who remained throughout the redrill of GB-ER.

The GB-2R redrill operations began in mid-June 1968, and were completed by mid-July 1968. They included the redrill of GB-2R and flow testing (flaring) of natural gas from the GB-ER well for 15 days. The project officer was onsite for these operations. Staff previously assigned to the project were on standby at SWRHL in the event additional field personnel were needed.

Air surveillance

The Project Gasbuggy Air Surveillance Network collected daily samples preshot and during the post-shot period at 35 locations surrounding the Gasbuggy site. Six of these stations were part of the SWRHL Air Surveillance Network (ASN) and two were activated ASN standby stations. The remaining 27 stations were established specifically for the project. The Gasbuggy network is shown in figure 3.

Air sampling stations were equipped with Gelman Tempest air samplers using a Gast Model-1550 positive displacement pump. The filter system used a 4-inch diameter Whatman-541 filter in series with a 4-inch MSA[2] activated charcoal cartridge.

The Gasbuggy Surveillance Network station began operations on November 27, 1967 and continued through December 13, 1967. The nine sta-

[2] MSA—Mine Safety Appliance, part 46727 charcoal cartridge. The cartridge is an organic-vapor-type cartridge containing stable iodine to improve the organic iodide retention capability.

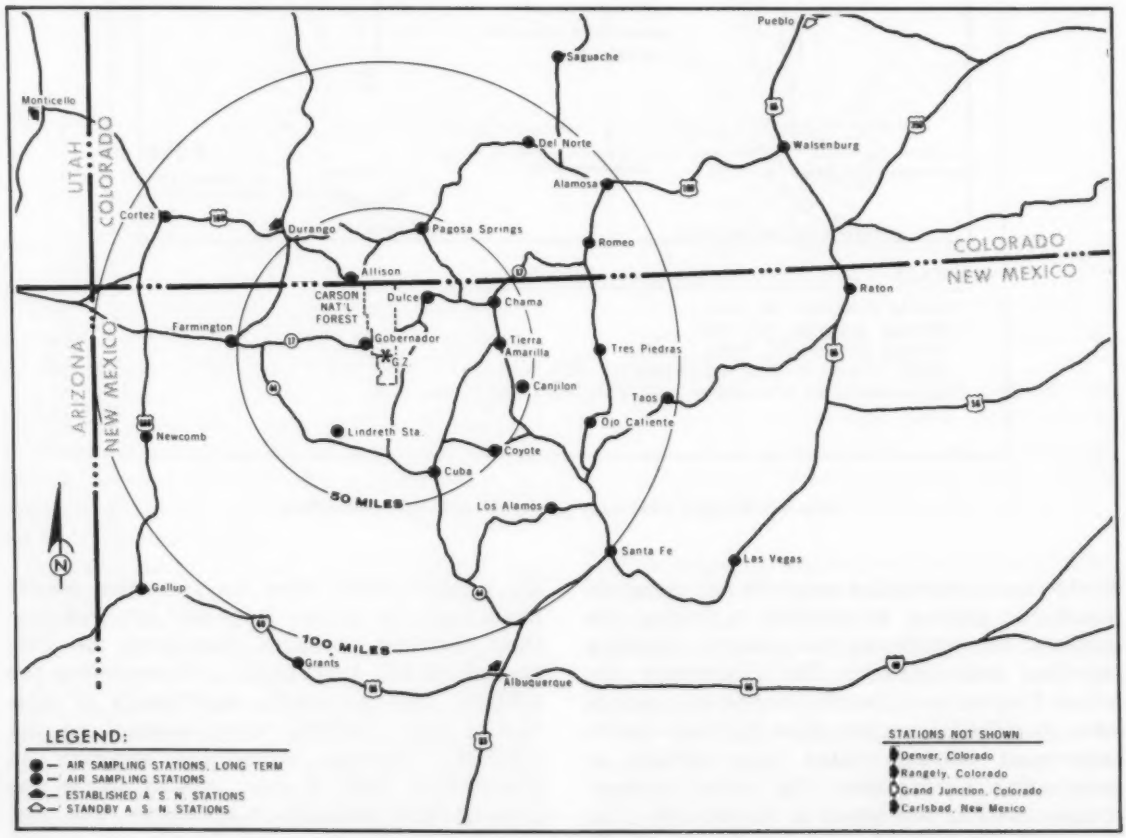

Figure 3. Project Gasbuggy air surveillance network

tions nearest the site were operated throughout the GB-ER drill-back period until January 19, 1968. A total of 1,120 sets of samples was collected. In mid-April 1968, 16 of the 27 special stations were discontinued, leaving 11 on standby. These stations were operated from June 30 to July 18, 1968. A total of 200 sets of samples was collected during this period.

All filters and charcoal cartridges were mailed directly to SWRHL for analysis. The filters were analyzed for beta radioactivity upon arrival at the laboratory and again on the fifth and twelfth day after collection. If the initial beta-particle count indicated a radioactivity concentration of more than 1 picocurie per cubic meter, or if the 5-day count was more than 150 counts per minute above background, the filter was analyzed by gamma-ray spectroscopy. The charcoal cartridge was gross gamma-ray counted upon arrival and, if the count was greater than 500 counts per minute, the filter and cartridge were analyzed by gamma-ray spectroscopy. These control limits were based on normal background concentrations.

The air sampling results for each of the three periods are summarized in table 1. The post-shot period is further divided into two periods since levels of radioactivity in air were generally higher across the United States during the last 5 days of December 1967.[3] Examples of this increase at scattered stations west of the Mississippi River are given in table 1 (footnote c).

Milk surveillance

Milk sampling coverage was provided by the Gasbuggy Milk Surveillance Network during the preshot and operational periods. Twenty-two stations were sampled; 13 represented family milk cows and nine were Grade-A dairies. The station locations are shown in figure 4.

Samples were collected at each location during the following periods: July 30 to August 1, 1967; September 4–7, 1967; October 20–25, 1967; and January 19–20, 1968. In addition, five samples were collected on December 14, 1967. A total of 75 1-gallon samples was collected and shipped to SWRHL for analysis.

The analysis of the 1-gallon milk samples consisted of two procedures: gamma-ray counting and radiochemical analysis for strontium. Upon arrival at SWRHL, 3½ liters of the sample were analyzed by gamma-ray spectroscopy for 40 minutes. The gamma-ray analysis information was proc-

[3] Additional information on increased levels can be found in reference 1.

Table 1. Summary of beta radioactivity in air[a] Gasbuggy air surveillance network

Period[b]	Number of stations operating	Number of samples taken	Number of samples above detectable limits	Range (pCi/m³)		Average of samples above detectable limits (pCi/m³)	Average of all samples (pCi/m³)
				Minimum	Maximum		
Period 1—preshot: 11/27/67 to 12/9/67	35	404	80	0.1	1.3	0.2	[c]<0.1
Period 2—post-shot: 12/10/67 to 12/24/67	[d]35 or 12	240	27	.1	.3	.1	<.1
12/25/67 to 1/19/68	[e]12 or 25	371	336	.1	7.8	1.0	.9
Selected ASN stations:[f] 12/25/67 to 1/19/68	5	105	63	.1	9.5	.8	.5
Period 3—GB-2R redrill: 6/13/68 to 7/18/68	10	200	190	.1	1.0	.2	.2

[a] Gamma-ray analysis results, none of which showed radioactivity above background, are available from SWRHL.
[b] 1/19/68 to 6/13/68—all stations on standby.
[c] Detectable limit: beta radioactivity—0.1 pCi/m³ based on 300 m³ and 2-minute-counting time.
[d] 12/10/67 to 12/13/67: 35 stations operated. 12/13/67 to 12/24/67: 12 stations operated.
[e] 1/12/67 to 1/11/68: 12 stations operated. 1/11/68 to 1/19/68: 25 stations operated.
[f] Selected ASN stations:

Station	Station no.	
Minneapolis	65	These scattered stations were selected to show that the increased radioactivity was widespread.
Berkeley	40	
Seattle	50	
Phoenix	43	
New Orleans	92	

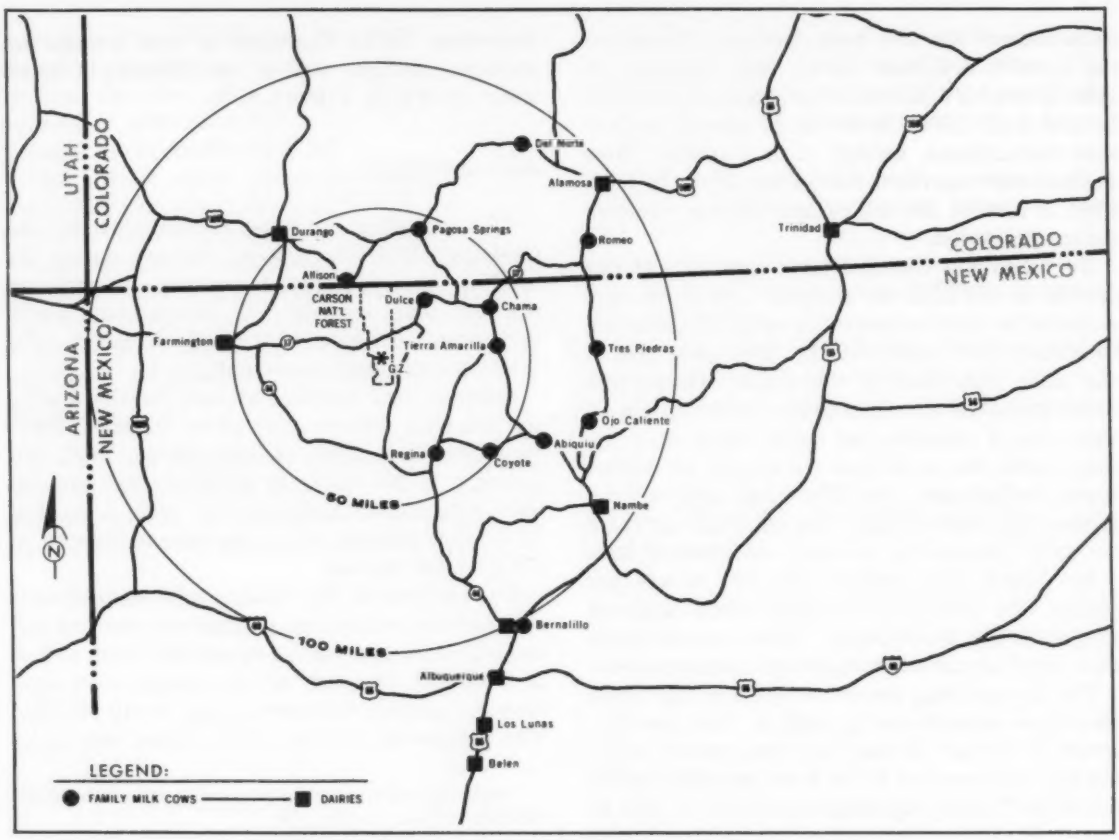

Figure 4. Project Gasbuggy milk surveillance network

essed through a computer program which quantified the samples for iodine–131, cesium–137, barium–140, and lanthanum–140. After the computer program completed the results, the spectroscopic information was examined to ascertain that no other radionuclides were present. The strontium analysis consisted of passing 1 liter of the sample through an ion-exchange resin column which retained the strontium. The strontium, after being eluted from the column, was precipitated as a carbonate compound and was counted after weighing and again 1 week later. The strontium–89 and –90 concentrations were solved by simultaneous equations.

The milk sampling results for periods 1 and 2 are summarized in table 2. No milk samples were taken following the GB-2R redrill (period 3) since all radioiodines had decayed below significant levels.

Water surveillance

Water sampling coverage during the preshot and post-shot periods was provided by a network of 34 sampling stations, shown in figure 5. Fifteen of the sampling locations were within 20 miles of ground zero at open- and well-water sources, and 13 of the locations were the same as the family milk cow sampling stations. Six of the network locations were municipal water systems located within approximately 120 miles from ground zero.

Seventy-four 1-gallon samples were collected on the same schedule as milk samples prior to the GB-2R redrill. Seven samples were collected during and immediately following the GB-2R redrill. All samples were sent to SWRHL for analysis. Upon arrival at SWRHL, 3½ liters of the sample were analyzed by gamma-ray spectroscopy for

Table 2. Summary of Gasbuggy milk analysis results, periods 1 and 2

Isotope	Number of samples analyzed	Number of samples above detectable limits[a]	Range (pCi/liter)		Average of samples above detectable limit (pCi/liter)	Average of all samples (pCi/liter)
			Minimum	Maximum		
Preshot:						
Iodine–131	52	0	—	—	—	ND
Cesium–137	52	6	10	34	20	<10
Strontium–89	30	4	5	5	5	< 5
Strontium–90	30	29	3	18	6	6
Post-shot:						
Iodine–131	23	0	—	—	—	ND
Cesium–137	23	1	16	16	16	<10
Strontium–89	20	2	5	5	5	< 5
Strontium–90	20	18	2	8	5	4

[a] Detectable limits: Iodine–131—10 pCi/liter, based on 3,500-ml sample counted for 40 min.
Cesium–137—10 pCi/liter, based on 3,500-ml sample counted for 40 min.
Strontium–89—5 pCi/liter, based on 1-liter sample counted for 50 min.
Strontium–90—2 pCi/liter, based on 1-liter sample counted for 50 min.

ND, nondetectable.

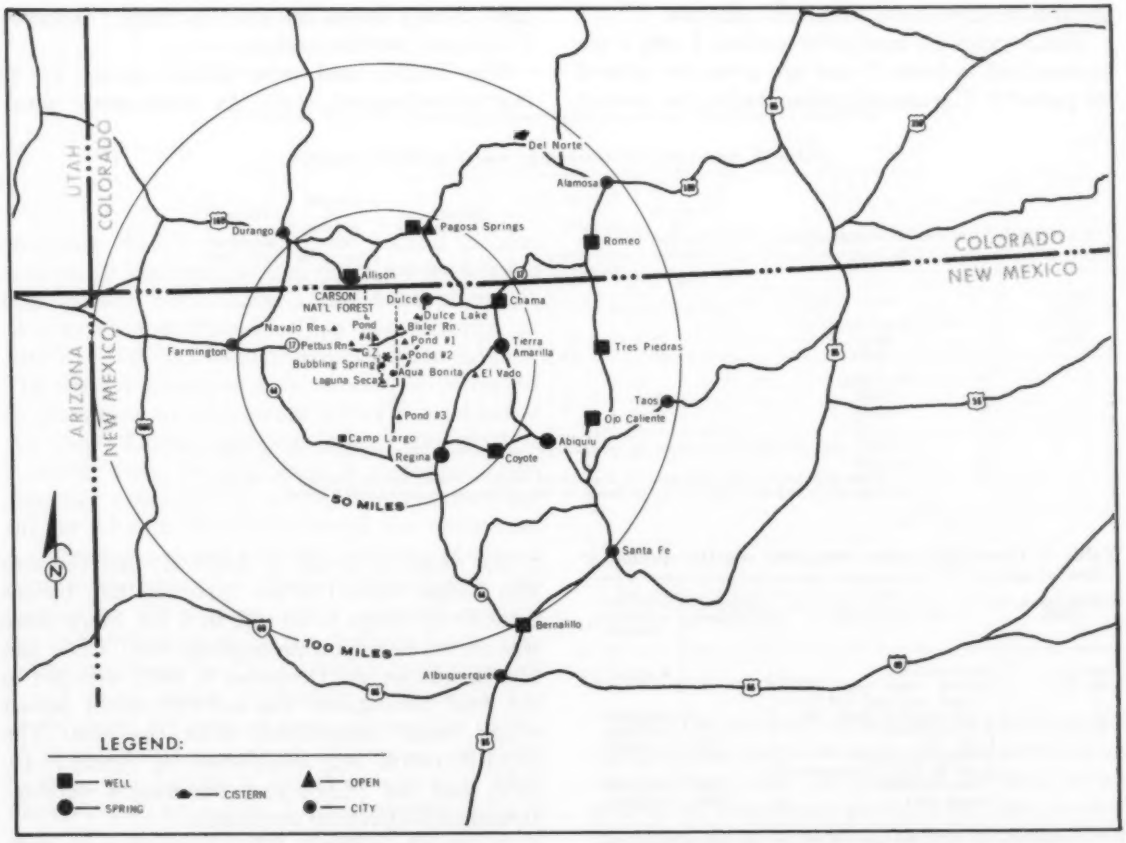

Figure 5. Project Gasbuggy water surveillance network

40 minutes. This information was processed through a computer program which routinely calculates values for the following isotopes; cerium-praseodymium–144, barium-lanthanum–140, cesium–137, iodine–131, ruthenium–106, zirconium–niobium–95, manganese–54, and potassium–40.

If it had been determined that additional analysis for other radionuclides was necessary, a different set of isotopes could have been specified. However, none of the samples required additional analysis. After the gamma-ray analysis, 250 milliliters of the sample were evaporated and the residue counted for gross alpha and gross beta radioactivity. If the gross beta radioactivity had been greater than 100 pCi/liter at the time of counting, a strontium analysis would have been performed; if the gross alpha radioactivity had been greater than 30 pCi/liter, a radium–226 analysis would have been done. None of the samples required these additional analyses.

Water sampling results for periods 1 and 2 are summarized in table 3 and are given in table 4 for period 3. The samples taken during the preshot and post-shot periods (periods 1 and 2) were treated routinely as samples are from all Nevada Test Site operations. The samples taken following the GB-2R redrill (period 3), however, were taken specifically for tritium analysis; beta and alpha-particle counting was not done and all gamma-ray spectra were negligible.

Personnel surveillance

A network of thermoluminescent dosimeters (TLD's) and film badges was established surrounding the Gasbuggy site. The network consisted of 50 stations located at approximately 1 and ½-mile intervals along existing roads and highways, as shown in figure 6.

The background radiation level for the network area was established prior to the shot with stations consisting of three "dedosed" TLD's set out on October 17, 1967, and exchanged on November 15, 1967. They were exchanged again on December 8, 1967, 2 days before the shot, for three "dedosed" TLD's and two film badges.

The TLD's used were EG&G model TL–12 thermoluminescent CaF_2:Mn dosimeters (sensitivity range of 4 mR to 5,000 R) and the two film badges were DuPont type 545 film badges (sensitivity range of 30 mR to 3 R). Since there was no venting upon detonation, the TLD's and film badges set out December 8, 1967, were left in the field throughout the GB-ER redrill period which began immediately after the shot. The GB-ER redrill was completed on January 10, 1968, and the TLD's and film badges were returned to SWRHL for evaluation.

An entirely different TLD network was established for the GB-2R redrill and GB-ER flaring

Table 3. Summary of Gasbuggy water analysis results[a]

Radioactivity	Number of samples counted	Number of samples above detectable limit[b]	Range (pCi/liter)		Average of samples above detectable limit (pCi/liter)	Average all samples (pCi/liter)
			Minimum	Maximum		
Preshot:						
Beta	76	52	2	40	8	5
Alpha	76	25	1	23	4	1
Post-shot:						
Beta	25	14	2	29	9	5
Alpha	25	7	1	16	3	1

[a] The concentrations determined by gamma-ray spectroscopy were negligible for all water samples.
[b] Detectable limits: beta radioactivity, 2 pCi/liter based on 250-ml sample counted for 50 minutes and alpha radioactivity, 1 pCi/liter based on 250-ml sample counted for 50 minutes.

Table 4. Gasbuggy water sampling results—period 3[a]

Date taken (1968)	Sample location	Tritium[b] (pCi/liter)	Gamma spectrum analysis
June 24	Pettus ranch		Negligible
June 27	Drilling water pond, Gasbuggy road and NM 17 (2 miles north of Pond #1)[c]		Negligible
July 16	Well and Pond #1	900	Negligible
	Pond #4	700	Negligible
	Drilling water pond	<400	Negligible
	Pond (2 miles southeast of Laguna Seca)[c]	800	Negligible
	Laguna Seca	<400	Negligible

[a] Period 3—GS–2 redrill and GB–ER and GB–2R flaring operations.
[b] Alpha and beta radioactivity counts were not made on these 7 samples. The tritium concentrations given are considered to be background.
[c] Not shown in figure 5.

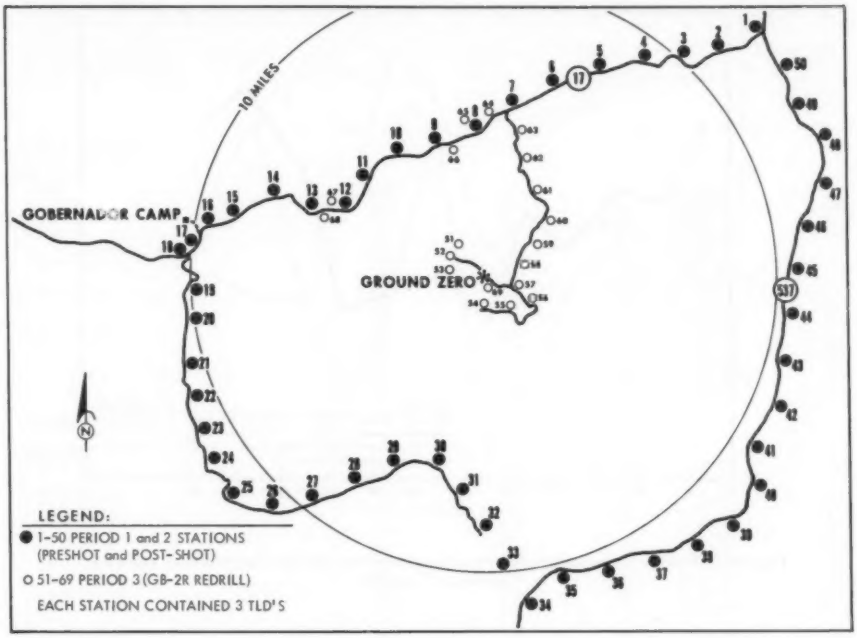

Figure 6. Project Gasbuggy thermoluminescent dosimeter stations

operation. TLD's were stationed around the site area at 19 locations ranging from 0.1 to 6 miles from ground zero. Three TLD's were placed at each location on June 27, 1968, and collected on July 16, 1968. The locations are shown in figure 6. The station locations were selected with regard to prominent wind direction during this period of the year. During daytime hours, the wind is primarily from the southwest. A stable condition generally exists during the nighttime hours when the air 'drains' downhill toward the northwest. A network was placed 1.3 miles northwest of ground zero, covering an arc from approximately 345 degrees to 180 degrees and a network crossing the valley through which the drainage winds pass.

The results of the TLD network during periods 1 and 2 are shown graphically in figure 7. The graph shows the average exposure recorded by the TLD stations located within 30-degree arcs. Table 5 gives the results of the less extensive TLD network used for period 3. Since the locations of most of the stations and length of exposure for the two networks were not the same, a direct comparison of the results should not be made.

Table 5. Gasbuggy thermoluminescent dosimeter results—period 3[a]

Station number[b]	Average daily exposure (mR)	Station number	Average daily exposure (mR)
51	0.28	62	0.14
52	.28	63	.25
53	.23	64	.27
54	.19	55	.28
55	.28	66	.27
56	.27	67	.28
57	.34	68	.25
58	.27	69	.27
59	.25		
60	.27	Controls–Farmington[c]	.27
61	.25		

[a] The actual period of exposure was June 27, 1968, to July 16, 1968.
[b] The station locations are given in figure 6.
[c] These dosimeters remained in Farmington to provide a comparative background for the period.

Natural gas surveillance

The PHS provided surveillance of radioactivity in the natural gas produced in the area surrounding the Gasbuggy site. This program consisted for an analysis for fresh fission products and natural radionuclides of the natural gas collected preshot and post-shot from all the wells and the gathering system located within 5 miles of ground zero.

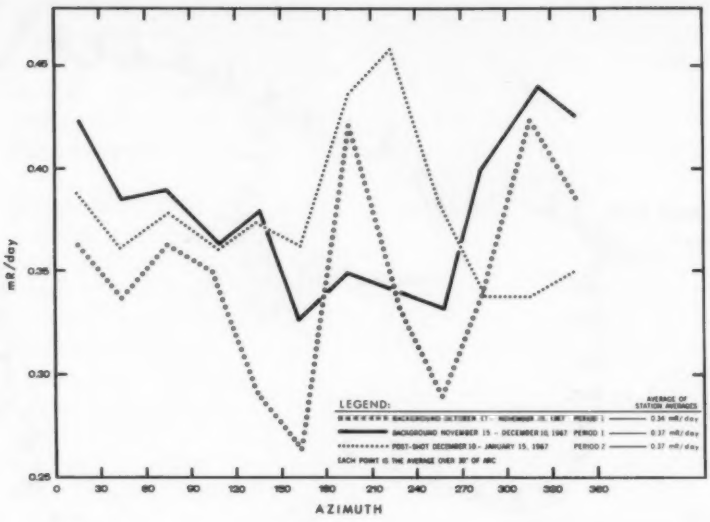

Figure 7. Project Gasbuggy thermoluminescent dosimeter station results periods 1 and 2

Fifteen samples were analyzed before the detonation to determine background radioactivity levels and 31 samples were analyzed after the detonation to check for increased levels of radiation. The results of these samples are given in table 6. In addition to the samples collected within 5 miles of ground zero, 12 samples were collected at more distant locations within the El Paso Natural Gas Company's system. The results of these samples are given in table 7. All samples were analyzed for radioistopes of xenon and krypton, and the radionuclides, radon–222, carbon–14, and tritium. The analysis of the gas samples showed no evidence of fresh fission products in any sample. Levels of radon–222 found in post-shot samples were no higher than the background levels found in preshot samples.[4]

As of June 1, 1969, all producing gas wells within a 5-mile radius of ground zero are still physically cut from the El Paso Natural Gas Company's distribution system. Plans for sampling gas on a periodic basis from these producing wells when they are returned to the distribution system are presently being considered by the Atomic Energy Commission.

Summary and conclusions

The offsite radiological safety program conducted by the Southwestern Radiological Health Laboratory for the U.S. Atomic Energy Commission documented that no detectable radioactivity was introduced into the offsite environment as a result of the Project Gasbuggy detonation. In addition, the SWRHL was adequately prepared so that personnel could effectuate emergency procedures to insure protection of the public health had an unforeseen accident occurred.

Initial gas samples collected from the producing wells within approximately a 5-mile radius of ground zero as well as sampling of the El Paso Natural Gas Company's distribution system have showed, as of July 1968, that no migration of radionuclides into other wells has occurred.

Project Gasbuggy represented no hazard from radioactivity to the population in the vicinity of the detonation site nor has it resulted in the introduction of any device-related radioactivity into the existing natural gas distribution system of the El Paso Natural Gas Company.

[4] For additional information on radon–222 values in gas produced in the San Juan Basin, see reference 2.

Table 6. Radon analyses from Gasbuggy preshot and post-shot natural gas sampling

Well	Formation[a]	Azimuth from ground zero	Distance from ground zero (miles)	Date collected	Radon–222 concentration[b] (pCi/ft³)
Preshot samples[c]:					
San Juan					
28–4 No. 26	MV	255°	5.15	9/19/67	1,068
	MV	255°	5.15	10/24/67	1,084
	MV	255°	5.15	11/14/67	1,034
29–4 No. 2	PC	274°	1.03	9/19/67	298
	PC	274°	1.03	10/16/67	[d]
30–4 No. 4[e]	PC	348°	8.54	9/19/67	[d]
	PC	348°	8.54	10/24/67	[d]
Indian E No. 1	PC	63°	1.27	9/19/67	[d]
	PC	63°	1.27	10/16/67	493
	PC	63°	1.27	11/21/67	470
Indian H No. 1[f]	PC	128°	4.70	9/19/67	179
	MV	128°	4.70	10/03/67	309
	PC	128°	4.70	10/24/67	199
	MV	128°	4.70	10/24/67	354
	PC	128°	4.70	11/07/67	204
Post-shot samples[c]:					
San Juan					
27–4 No. 1	MV	179°	5.40	1/02/68	34
	MV	179°	5.40	1/30/68	9
28–4 No. 1	MV	260°	4.40	12/27/67	520
28–4 No. 2	MV	251°	4.07	12/27/67	146
28–4 No. 6	PC	218°	.59	2/27/68	288
28–4 No. 7	PC	126°	2.14	2/27/68	239
28–4 No. 8	MV	178°	4.56	1/30/68	1,028
28–4 No. 13	MV	136°	4.60	12/26/67	1,165
28–4 No. 14	MV	228°	4.50	12/27/67	230
28–4 No. 16	MV	235°	5.30	12/26/67	859
28–4 No. 17	MV	240°	3.83	12/26/67	754
28–4 No. 26	MV	255°	5.15	12/20/67	1,628
28–4 No. 27	MV	243°	5.45	12/26/67	1,080
28–4 No. 28	MV	246°	4.79	12/26/67	70
29–4 No. 1	MV	282°	5.12	12/20/67	79
29–4 No. 2	PC	274°	1.03	2/27/68	302
29–4 No. 4	PC	309°	.84	2/27/68	464
29–4 No. 10[g]	PC	344°	.10	NS	
29–4 No. 14	MV	277°	4.45	12/27/67	34
29–4 No. 16	PC	39°	.72	2/27/68	483
29–4 No. 18	MV	280°	2.49	12/26/67	592
30–4 No. 4[e]	PC	348°	8.54	12/12/67	333
Indian A No. 2	PC	43°	1.28	12/27/67	480
Indian E No. 1	PC	63°	1.27	12/27/67	52
Indian I No. 1[f]	MV	139°	5.65	12/19/67	617
	PC	139°	5.65	12/19/67	761
	PC	139°	5.65	1/30/68	9
Indian B No. 1	MV	136°	4.58	12/19/67	216
Indian L No. 2	MV	129°	3.96	1/02/68	18
Indian H No. 1[f]	PC	128°	4.70	12/19/67	244
	MV	128°	4.70	12/19/67	484
San Juan					
28–4 No. 21	MV	265°	4.93	12/27/67	634

[a] Gas bearing formation: MV is Mesa Verde formation, PC is Pictured Cliffs formation.

[b] The minimum level of detection (MLD) for radon–222 is 1 pCi/ft³. Similarly MLD's for other isotopes analyzed are: xenons —200 pCi/ft³
kryptons —200 pCi/ft³
carbon–14—300 pCi/ft³
tritium — 20 pCi/ft³
All radon–222 values have been corrected for decay to the time of sample collection.

[c] The table only contains concentrations for radon–222. The samples were also analyzed for radioxenons, radiokryptons, carbon–14, and tritium. Results of these analyses were all below minimum detectable levels shown in footnote [b]. All radons on preshot samples were analyzed at the field laboratory in Farmington. All post-shot radon analyses were performed in Las Vegas. The Farmington analyses were carried out on raw natural gas while the Las Vegas analyses were made by separating the radon from the natural gas. The Las Vegas results have been corrected by an appropriate correction factor to make them comparable to the preshot Farmington results.

[d] These samples were not analyzed for radon–222, but were analyzed for xenon and krypton radioisotopes.

[e] This well is located outside of the area bounded by a 6-mile radius from ground surface zero.

[f] Samples from Indian H No. 1 and Indian I No. 1 wells can be taken from one or both the Pictured Cliffs (PC) and Mesa Verde (MV) formations because these wells penetrate both formations.

[g] This well is also called 10–36 and is located 435 feet from ground zero. It was stemmed prior to the event and could not be sampled post-shot.

NS, no sample taken.

Table 7. Special post-Gasbuggy natural gas samples

Sample description	Collection date (1968)	Radon-222 concentrations[a] (pCi/ft^3) Average of 3 analyses
Mainline, blockvalve 3-mile post 36+	4/24	260
	4/24	404
24-inch main and loop blockvalve 2	4/24	475
24-inch main, blockvalve 2	4/24	713
San Juan 29-5 unit 45 22 MD-R.A. Mesa Verde	4/25	1,005
San Juan 28-5 unit 55 R.A. Mesa Verde	4/25	1,132
San Juan 28-5 unit 45 R.A. Dakota	4/25	275
San Juan 28-5 unit 19 R.A. Picture Cliffs	4/25	484
San Juan 27-4 unit 13 R.A. Picture Cliffs	4/25	[b] 761
San Juan 30-4 unit 4 R.A. Picture Cliffs	4/25	405
Ehrenberg meter station	4/26	164
Topok meter station	4/26	294

[a] Corrected for decay to the time of sample collection.
[b] Duplicate analysis.
Note: Each sample was analyzed for tritium, carbon-14, radioxenon, and radiokrypton. No radioactivity was detected above minimum detectable levels of 20, 300, 200, and 200 pCi/ft^3, respectively.

Representative products and manufacturers are named for identification only and listing does not imply endoresement by the Public Health Service and the U.S. Department of Health, Education, and Welfare.

REFERENCES

(1) PUBLIC HEALTH SERVICE. Radiation Alert Network, December 1967. Radiol Health Data Rep 9:226–229 (April 1968).

(2) BUNCE, L. A. and F. W. SATTLER. Radon-222 in natural gas. Radiol Health Data Rep 7:441–444 (August 1966).

Technical Notes

Evaluation of Radium-226 in Total Diet Samples, 1964 to June 1967[1]

Northeastern Radiological Health Laboratory
Bureau of Radiological Health

A summary of concentrations of radium–226 in total diet samples collected by the Institutional Total Diet Network, Bureau of Radiological Health, from 1964 to the middle of 1967, is presented in this report. The purpose of this summarization is to characterize the internal exposure to the population from ingested radium–226 and to determine if significant environmental differences due to geographical or seasonal variations influence the concentration of this radionuclide in the total diet.

The data used in this evaluation were obtained from *Radiological Health Data and Reports* (*1*). A detailed description of sampling and analytical procedures is presented in reference 2. The minimum detectable sensitivity for analysis of radium–226 in food is 0.1 pCi/kg.

The following locations provided a sufficient amount of continuous data for this evaluation:

Boston, Mass.	Denver, Colo.
Chicago, Ill.	Pittsburgh, Pa.
Cleveland, Ohio	Idaho Falls, Idaho
Burlington, Vt.	Honolulu, Hawaii
Palmer, Alaska	Wilmington, Del.
Seattle, Wash.	

The data from each location were plotted on arithmetic probability paper in order to characterize some common statistical variables. These graphs are shown in figures 1, 2, and 3. Results from Chicago, Ill.; Boston, Mass.; Cleveland, Ohio; and Burlington, Vt. (figure 1) show a normal distribution. Data from Denver, Colo.; Seattle, Wash.; Pittsburgh, Pa.; and Palmer, Alaska (figure 2) have a bimodal distribution, with a discontinuity above the 87 percentile (1.5σ level). Wilmington, Del., and Honolulu, Hawaii, also have bimodal distributions with the discontinuity occurring at approximately the 25 percentile. Idaho Falls, Idaho, appears to have a trimodal distribution. These latter graphs appear in figure 3. Changes in sampling methods and sites, and in analytical procedures, cannot be ruled out as possible factors in causing the resultant distribution to vary from normal. Information on environmental variables which might influence the distribution of the data is lacking, but plotting the data against a time scale appears to indicate that the variations in the data at any one location are not related to seasonal factors.

The mean, 1σ range and 1.5σ range for radium–226 concentrations in total diet samples from 1964 to the middle of 1967 are shown in table 1. The

Table 1. Radium-226 in total diet from 1964 to the middle of 1967

Sampling location	Mean	Concentration (pCi/kg) 1σ range	1.5σ range
Mass: Boston	0.52	0.44–0.60	0.35–0.71
Alaska: Palmer	.54	.43– .64	.31– .78
Ill: Chicago	.58	.51– .67	.40– .78
Idaho: Idaho Falls	.58	.48– .68	.41– .82
Wash: Seattle	.61	.40– .72	.38– .85
Colo: Denver	.61	.40– .72	.38– .85
Ohio: Cleveland	.62	.52– .71	.42– .83
Vt: Burlington	.62	.52– .74	.42– .88
Hawaii: Honolulu	.64	.51– .77	.46– .88
Del: Wilmington	.70	.61– .85	.48–1.12
Pa: Pittsburgh	.73	.66– .84	.56– .95
Summary		0.40–0.85	0.31–1.12

[1] Special report prepared by Dr. Bernard Shleien, chief, Environmental Radiation Activities, Northeastern Radiological Health Laboratory, Winchester, Mass.

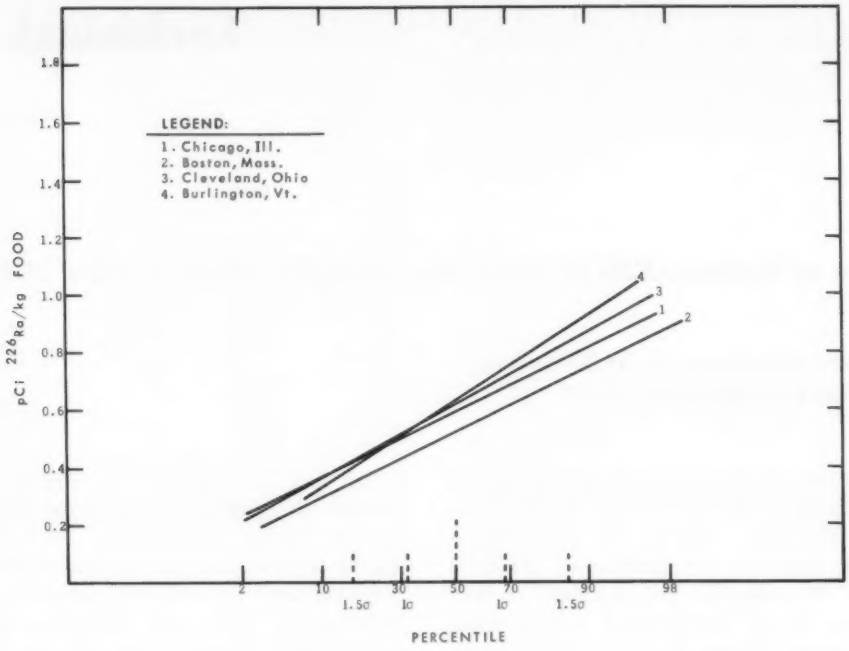

Figure 1. Percentile distribution of radium-226 in total diet for four selected cities

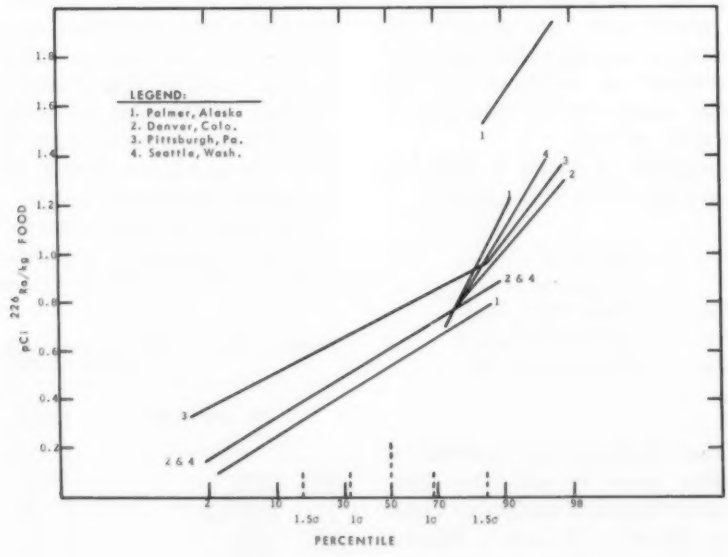

Figure 2. Percentile distribution of radium-226 in total diet for four selected cities

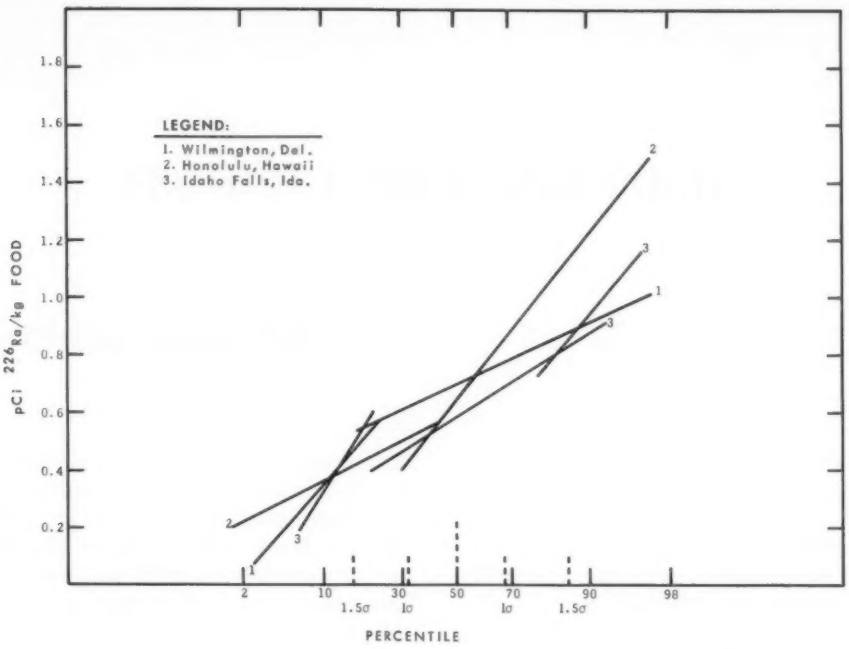

Figure 3. Percentile distribution of radium-226 in total diet for three selected cities

mean values varied from 0.52 to 0.73 pCi/kg. In no case was the 1.5σ range greater than 60 percent of the mean value. In other words, 87 percent of the results at any one station were within 60 percent of the mean value. In considering all the data, 87 percent of the results fell between 0.31 pCi/kg and 1.12 pCi/kg, a factor of slightly less than 4.

Assuming a food consumption of 2 kg per day, these results indicate that radium–226 intake is for the most part in Range I (0–2 picograms per day) of the Federal Radiation Council's guidance on transient rates of daily intake of radium–226 and would not be expected to result in any appreciable number of individuals in the population reaching a large fraction of the Radiation Protection Guide (*3*). The FRC then states: "Therefore, if calculations based upon a knowledge of the sources of release of radioactive materials to the environment indicate that the intakes of the population are in this range the only action required is surveillance adequate to provide reasonable confirmation of calculations."

In summary, results of three and one-half years of total diet surveillance at eleven diverse geographical locations indicate that approximately 87 percent of the samples analyzed for radium–226 would result in daily human intakes within Range I of the FRC recommendations for this radionuclide. Therefore, it appears that this is "surveillance adequate to provide reasonable confirmation of calculations." Furthermore, since the sources of release are not usually subject to human manipulation, further evaluation of radium–226 content in food in the manner presently performed appears to be superfluous.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Radionuclides in Institutional diet samples, annual averages 1964. Radiol Health Data 6:371–377 (July 1965); annual summary 1965, Radiol Health Data Rep 7:398–403 (July 1966); January–March 1967 and annual summary 1966, Radiol Health Data Rep 8:591–596 (October 1967); October–December and annual summary 1967, Radiol Health Data Rep 9:359–363 (July 1968).

(*2*) PUBLIC HEALTH SERVICE. Radionuclides in Institutional diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(*3*) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

SECTION I. MILK AND FOOD

Milk Surveillance, August 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Bureau of Radiological Health, Environmental Control Administration and the Bureau of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations
Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium–89, strontium–90, iodine–131, cesium–137, and barium–140. A sixth radionuclide, potassium–40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium–40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have

Figure 1. Milk sampling networks in the Western Hemisphere

been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use of general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in December 1968, with 37 laboratories participating in an experiment on milk samples containing known concentrations of strontium–89, strontium–90, iodine–131, and cesium 137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 participated in the experiment.

In general the results for iodine–131 and cesium–137 are encouraging, but the results for strontium–89 and strontium–90 need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium–40, iodine–131, cesium–137, and barium–140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium–90 and cesium–137 are relatively stable over short-time periods and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine–131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium–90 and cesium–137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-

standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium–89	5
Strontium–90	2
Iodine–131	10
Cesium–137	10
Barium–140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurement equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium–89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium–90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine–131, Cesium–137, Barium–140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine–131, cesium–137, and barium–140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8,9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practical. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	RPG (rad/yr)	Guidance for suitable samples of exposed population group[a]			
				Corresponding continuous daily intake (pCi/day)	Range I[b] (pCi/day)	Range II[b] (pCi/day)	Range III[b] (pCi/day)
Strontium-89	Bone	[c] 1.5	0.5	[d] 2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[c] 1.5	.5	[d] 200	0–20	20–200	200–2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium–89, strontium–90—general population; iodine–131—children 1 year of age: cesium–137—infants.
[b] Based on an average intake of 1 liter of milk per day.
[c] A dose of 1.5 rad/yr to the bone is estimated to result in a dose of 0.5 rad/yr to the bone marrow.
[d] For strontium–89 and strontium–90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.
[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protection Action Guide (*10,11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.
[b] Total dose from strontium–89 and cesium–137 is the same as dose in first year; total dose from strontium–90 is 5 times strontium–90 dose in first year for children approximately 1 year of age.
[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.
[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

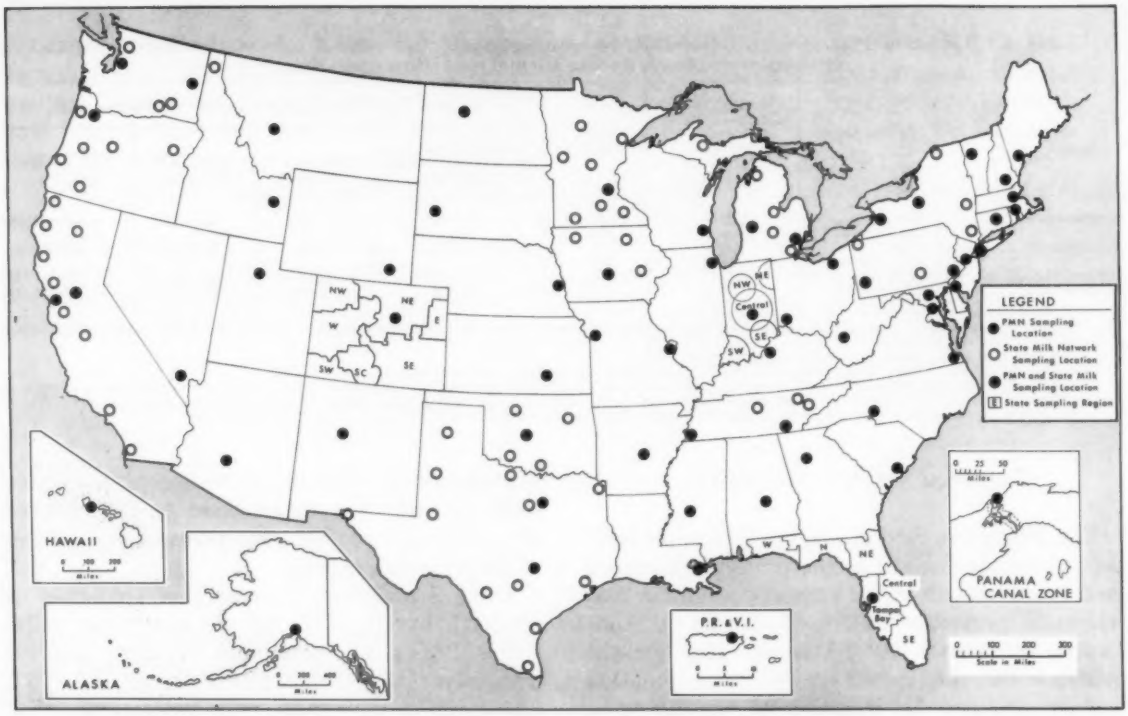

Figure 2. State and PMN milk sampling locations in the United States

maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

Discussion of current data

In table 3, surveillance results are given for strontium–89, strontium–90, iodine–131, and cesium–137 for August 1969 and the 12-month period, September 1968–August 1969. Except where noted the monthly average represents a single sample for the sampling station. Barium–140 data has been omitted from table 3 since levels at all the stations for August 1969 were below the respective practical reporting levels.

Iodine-131 results are included in the table, even though they were generally below practical

Table 3. Concentration of radionuclides in milk for August 1969 and 12-month period, September 1968 through August 1969

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)							
		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES									
Ala: Montgomery[c]	P	4 (4)	1	4 (4)	6	0 (4)	0	15 (4)	11
Alaska: Palmer[c]	P	NS	0	NS	6	NS	0	NS	9
Ariz.: Phoenix[c]	P	0	0	0	1	0 (4)	0	0 (4)	0
Ark: Little Rock[c]	P	4 (4)	1	16 (4)	18	0 (4)	0	23 (4)	18
Calif: Sacramento[c]	P	0	0	0	2	0 (4)	0	0 (4)	1
San Francisco[c]	P	0	0	0	2	0 (4)	0	0 (4)	0
Del Norte	P	6	8	14	21	0	0	0	17
Fresno	P	0	0	0	0	0	0	0	1
Humboldt	P	0	2	4	5	0	0	0	9
Los Angeles	P	0	0	0	1	0	0	0	2
Mendocino	P	0	0	3	3	0	0	0	2
Sacramento	P	0	0	0	3	0	0	0	2
San Diego	P	0	0	0	0	0	0	0	1
Santa Clara	P	0	0	0	0	0	0	0	3
Shasta	P	0	0	0	3	0	0	0	5
Sonoma	P	0	0	0	2	0	0	0	2
Colo: Denver[c]	P	7	2	3	5	0 (4)	0	0 (4)	2
Western	R	NS		NS		NS		NS	
Northeastern	R	NS		NS		NS		NS	
Eastern	R	NS		NS		NS		NS	
Southeast	R	NS		NS		NS		NS	
South Central	R	NS		NS		NS		NS	
Conn: Hartford[c]	P	[d]	0	10	8	0 (4)	0	11 (4)	12
Central	P	0	0	9	7	0 (4)	0	16 (4)	10
Del: Wilmington[c]	P	[d]		11	9	0 (4)	0	12 (4)	8
D.C.: Washington[c]	P	0 (5)	1	8 (5)	8	0 (5)	0	8 (5)	4
Fla: Tampa[c]	P	2 (4)	0	5 (4)	7	0 (4)	0	65 (4)	61
West	R	[d]		14	12	0	0	27	24
North	R	[d]		13	14	0	0	20	32
Northeast	R	[d]		7	8	0	0	78	67
Central	R	[d]		7	8	0	0	70	61
Tampa Bay area	R	[d]		6	8	0	0	64	66
Southeast	R	[d]		7	9	0	0	101	111
Ga: Atlanta[c]	P	0 (4)	0	9 (4)	11	0 (4)	0	18 (4)	19
Hawaii: Honolulu[c]	P	0 (4)	0	0 (4)	3	0 (4)	0	0 (4)	1
Idaho: Idaho Falls[c]	P	10	2	3	5	0 (4)	0	3 (4)	7
Ill: Chicago[c]	P	9	2	8	8	0 (4)	0	7 (4)	10
Ind: Indianapolis[c]	P	[d]		8	8	0 (4)	0	8 (4)	6
Northeast	P	0	0	10	12	0	0	15	10
Southeast	P	0	0	5	8	0	0	15	15
Central	P	0	0	6	10	0	0	10	10
Southwest	P	0	0	7	8	0	0	15	10
Northwest	P	0	0	8	10	0	0	25	15
Iowa: Des Moines[c]	P	7	1	6	6	0 (4)	0	3 (4)	3
Iowa City	P	NS		NS	NS	NS		NS	
Des Moines	P	NS		NS	NS	NS		NS	
Spencer	P	NS		NS	NS	NS		NS	
Charles City	P	NS		NS	NS	NS		NS	
Kans: Wichita[c]	P	6	1	7	7	0 (4)	0	0 (4)	2
Ky: Louisville[c]	P	3 (4)	2	9 (4)	10	0 (4)	0	5 (4)	6
La: New Orleans[c]	P	8 (4)	2	16 (4)	17	0 (4)	0	21 (4)	20
Maine: Portland[c]	P	[d]		14	12	0 (4)	1	30 (4)	25
Md: Baltimore[c]	P	1 (4)	1	8 (4)	9	0 (4)	0	14 (4)	7
Mass: Boston[c]	P	7	1	15	11	0 (5)	0	27 (5)	21
Mich: Detroit[c]	P	[d]		8	8	0 (4)	0	6 (4)	10
Grand Rapids[c]	P	[d]		12	11	0 (4)	0	10 (4)	14
Bay City	P	[d]		NS	5	NS	[e]	NS	11
Charlevoix	P	[d]		10	10	[e] (3)	[e]	26 (3)	18
Detroit	P	[d]		5	5	[e] (4)	[e]	9 (4)	5
Grand Rapids	P	[d]		7	7	[e] (4)	[e]	16 (4)	11
Lansing	P	[d]		8	5	[e] (2)	[e]	20 (2)	8
Marquette	P	[d]		10	9	8 (2)	[e]	31 (2)	28
Monroe	P	[d]		3	3	[e] (2)	[e]	6 (2)	1
South Haven	P	[d]		NS	7	NS	[e]	NS	8
Minn: Minneapolis[c]	P	12	2	7	10	0 (4)	0	16 (4)	12
Bemidji	P	[d]		20	17	0	0	35	23
Mankato	P	[d]		10	7	0	0	0	0
Rochester	P	[d]		10	9	0	0	11	0
Duluth	P	[d]		22	19	0	0	22	26
Worthington	P	[d]		8	8	0	0	0	0
Minneapolis	P	[d]		14	12	0	0	11	11
Fergus Falls	P	[d]		10	8	0	0	0	0
Little Falls	P	[d]		10	10	0	0	12	15
Miss: Jackson[c]	P	0 (4)	1	13 (4)	14	0 (4)	0	14 (4)	15
Mo: Kansas City[c]	P	6	4	11	7	0 (5)	0	3 (5)	2
St. Louis[c]	P	7	1	7	9	0 (4)	0	3 (4)	4
Mont: Helena[c]	P	0	1	4	5	0 (4)	0	3 (4)	7
Nebr: Omaha[c]	P	6	3	6	6	0 (5)	0	0 (5)	2
Nev: Las Vegas[c]	P	0	0	0	1	0 (4)	0	0 (4)	1
N.H.: Manchester[c]	P	[d]		8	9	3 (4)	0	22 (4)	24
N.J.: Trenton[c]	P	[d]		13	9	0 (5)	0	13 (5)	9

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for August 1969 and 12-month period September 1968 through August 1969—Continued

Sampling location	Type of sample[a]	Radionuclideconcentration (pCi/liter)							
		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Con									
N. Mex: Albuquerque[c]	P	0	0	0	2	0 (4)	0	0 (4)	1
N.Y.: Buffalo[c]	P	0 (2)	0	8 (2)	7	0 (4)	0	15 (4)	9
New York City[c]	P	(d)		13	10	0 (4)	0	15 (4)	13
Syracuse[c]	P	(d)		10	8	0 (4)	0	8 (4)	8
Albany	P	9	0	6	7	0 (3)	0	(e) (3)	(e)
Buffalo	P	16	0	0	5	0	0	(e)	(e)
Messena	P	12	0	8	10	0 (2)	0	(e) (2)	(e)
Newburg	P	0	0	0	11	0	0	(e)	(e)
New York City	P	10	0	6	11	0 (3)	0	(e)	(e)
Syracuse	P	11	0	0	8	0	0	(e)	(e)
N.C.: Charlotte[c]	P	0 (3)	1	12 (3)	15	0 (3)	0	17 (3)	12
N. Dak: Minot[c]	P	14	4	9	10	0 (4)	0	12 (4)	13
Ohio: Cincinnati[c]	P	(d)		10	8	0 (3)	0	0 (3)	3
Cleveland[c]	P	(d)		9	8	0 (4)	0	7 (4)	7
Okla: Oklahoma City[c]	P	0	1	7	8	0	0	14	10
Oklahoma City	P	NS		NS		NS		NS	
Enid	P	NS		NS		NS		NS	
Tulsa	P	NS	NS	NS		NS		NS	
Lawton	P	NS		NS		NS		NS	
Admore	P	NS		NS		NS		NS	
Ore: Portland[c]	P	0	2	8	7	0 (4)	0	1 (4)	8
Baker	P	(d)		NA	3	(e)	(e)	(e)	8
Coos Bay	P	(d)		NA	6	(e)	(e)	(e)	12
Eugene	P	(d)		NA	4	(e)	(e)	30	11
Medford	P	(d)		NA	2	(e)	(e)	23	16
Portland composite	P	(d)		NA	4	(e)	(e)	(e) (3)	6
Portland local	P	(d)		NA	5	(e)	(e)	(e) (3)	1
Redmond	P	(d)		NA	1	(e)	(e)	(e)	5
Tillamook	P	(d)		NA	8	(e)	(e)	20	20
Pa: Philadelphia[c]	P	(d)		11	8	0 (4)	0	8 (4)	5
Pittsburgh[c]	P	(d)		15	12	0 (4)	0	5 (4)	8
Dauphin	P	(d)		11	8	0	2	6	15
Erie	P	(d)		19	11	0	3	19	18
Philadelphia	P	(d)		NS	9	NS	1	NS	14
Pittsburgh	P	(d)		13	10	0	2	25	17
R.I.: Providence	P	(d)		11	9	0 (4)	0	20 (4)	17
S.C.: Charleston[c]	P	0 (4)	0	12 (4)	12	0 (4)	0	29 (4)	24
S. Dak: Rapid City[c]	P	17	4	12	8	0 (3)	0	6 (3)	7
Tenn: Chattanooga[c]	P	2 (4)	2	11 (4)	12	0 (4)	0	18 (4)	13
Memphis[c]	P	0 (4)	1	8 (4)	9	0 (4)	0	6 (4)	6
Chattanooga	P	8	4	14	14	0 (4)	0	14 (4)	16
Clinton	P	0	2	15	16	0	0	0	16
Knoxville	P	0	1	11	11	0 (2)	1	7 (2)	8
Nashville	P	0	2	9	9	0 (3)	0	15 (3)	6
Tex: Austin[c]	P	0 (4)	0	4 (4)	2	0 (4)	0	5 (4)	4
Dallas[c]	P	0 (4)	1	5 (4)	7	0 (4)	0	3 (4)	6
Amarillo	R	(d)		4	3	0	0	0	0
Corpus Christi	R	(d)		2	4	0	0	0	0
El Paso	R	(d)		2	2	0	0	0	0
Fort Worth	R	(d)		4	5	0 (4)	0	0	5
Harlengen	R	(d)		3	3	0	0	0	0
Houston	R	(d)		6	7	0	0	15	19
Lubbock	R	(d)		4	3	0	0	0	0
Midland	R	(d)		2	2	0	0	0	0
San Antonio	R	(d)		5	3	0	0	0	0
Texarkana	R	(d)		15	12	0	0	15	16
Uvalde	R	(d)		2	1	0	0	0	0
Wichita Falls	R	(d)		NS	7	NS	0	NS	10
Utah: Salt Lake City[c]	P	8	1	0	4	0 (4)	0	4 (4)	8
Vt: Burlington[c]	P	(d)		9	8	0 (4)	0	15 (4)	12
Va: Norfolk[c]	P	4 (5)	0	11 (5)	10	0 (5)	0	8 (5)	7
Wash: Seattle[c]	P	0	1	10	8	0 (4)	0	9 (4)	16
Spokane[c]	P	0	1	6	6	0 (4)	0	0 (4)	6
Benton County	R	(d)		NS	1	NS	0	NS	6
Franklin County	R	(d)		0	1	0	0	0	0
Sandpoint, Idaho	R	(d)		14	11	0	0	47	27
Skagit County	R	(d)		7	7	0	0	25	13
W. Va: Charleston[c]	P	2 (4)	1	11 (4)	10	0 (4)	0	5 (4)	8
Wisc: Milwaukee[c]	P	(d)		10	7	0 (4)	0	12 (4)	12
Wyo: Laramie[c]	P	0	1	5	5	0 (4)	0	1 (4)	10
CANADA									
Alberta: Calgary	P	(d)		10	8	(d)		26	17
Edmonton	P	(d)		8	7	(d)		24	17
British Columbia: Vancouver	P	(d)		11	13	(d)		41	39

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for August 1969 and 12-month period September 1968 through August 1969—Continued

Sampling location	Type of sample[a]	Radionuclideconcentration (pCi/liter)							
		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued									
Manitoba:									
Winnipeg	P	[d]		9	9	[d]		30	26
New Brunswick:									
Fredericton	P	[d]		14	14	[d]		25	20
Newfoundland:									
St Johns	P	[d]		12	18	[d]		61	37
Nova Scotia:									
Halifax	P	[d]		9	10	[d]		24	21
Ontario: Ft. William	P	[d]		13	16	[d]		32	32
Ottawa	P	[d]		8	9	[d]		16	17
Sault Ste. Marie	P	[d]		19	16	[d]		48	34
Toronto	P	[d]		3	5	[d]		9	13
Windsor	P	[d]		4	6	[d]		10	13
Quebec: Montreal	P	[d]		11	9	[d]		18	18
Quebec	P	[d]		9	11	[d]		26	27
Saskatchewan:									
Regina	P	[d]		8	7	[d]		15	15
Saskatoon	P	[d]		7	8	[d]		13	15
CENTRAL AND SOUTH AMERICA:									
Columbia:									
Bogota	P	NS		NS		NS		NS	
Chile: Santiago	P	0	4	0	0	0	0	0	0
Ecuador: Quayquil	P	0	3	0	0	0	0	0	0
Jamaica: Kingston	P	NS		NS		NS		NS	
Venesuela:									
Caracas	P	0	1	3	1	0	0	0	0
Canal Zone:									
Cristobal[e]	P	1 (4)	4	0 (4)	1	0 (4)	0	4 (4)	13
Puerto Rico:									
San Juan[e]	P	3 (4)	0	1 (4)	4	0 (4)	0	17 (4)	8
PMN network averages[f]		3	1	8	8	0	0	10	10

[a] P, pasteurized milk, R, raw milk.
[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses
[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.
[d] Radionuclide analysis not routinely performed.
[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter; Michigan—14 pCi/liter; Oregon—15 pCi/liter
Cesium-137: Colorado—25 pCi/liter; New York—20 pCi/liter; Oregon—11 pCi/liter
Strontium-90: New York—3 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote [e].
NA, no analysis.
NS, no sample.

reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting levels for iodine–131 are numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium–89 monthly averages ranged from 0 to 17 pCi/liter in the United States for the month of August 1969 and the highest 12-month average was 8 pCi/liter (Del Norte, Calif.) representing 0.4 percent of the recommended guide (table 1). Strontium–90 monthly averages ranged from 0 to 22 pCi/liter for the month of August 1569 and the highest 12-month average was 21 pCi/liter (Del Norte, Calif.) representing 10.5 percent of the recommended guide (table 1). Cesium–137 monthly averages ranged from 0 to 101 pCi/liter in the United States for the month of August 1969 and the highest 12-month average was 111 pCi/liter (southeast Florida), representing 3 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium–137 levels that have been observed in Florida (*12*) and Jamaica. Iodine–131 monthly averages were all below the practical reporting level.

Acknowledgement

Appreciation is expressed to the personnel of the following health agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

REFERENCES

(1) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium–90, iodine–131, and other radionuclides in milk, May 1967 through April 1968. Amer J Public Health 49:225 (February 1959).
(2) Chart of the Nuclides, Ninth Edition revised to July 1966. Knolls Atomic Power Laboratory (November 1966).
(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).
(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).
(5) KNOWLES, F. Interlaboratory study of iodine–131, cesium–137, strontium–89, and strontium–90 measurements in milk, December 1968. Technical experiment 68–MKAQ–2, Analytical Quality Control Service, Bureau of Radiological Health (December 1968).
(6) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621–627 (November 1967).
(7) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).
(8) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).
(9) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).
(10) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).
(11) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium–89, strontium–90, and cesium–137, Report No. 7. Superindent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).
(12) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The Cause of Relatively High Cesium–137 Concentrations in Tampa, Florida, Milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Issue
California Diet Study	November 1967–September 1968	May 1969
Connecticut Diet Study	January–June 1968	November 1968
Institutional Diet, *PHS*	Annual summary 1968 and January–March 1969	October 1969

1. Strontium-90 in Tri-City Diets[1] August–December 1968

Health and Safety Laboratory
U.S. Atomic Energy Commission

Estimates of the average intake of strontium–90 by New York City, Chicago, and San Francisco residents have been made by the Health and Safety Laboratory (HASL). These estimates were made by using measurements of the strontium–90 content of a large variety of foods purchased at the cities every 3 months and statistics on the average consumption of each food compiled by the U.S. Department of Agriculture in their 1955 Household Diet Survey (*1*). A detailed description of the aims and methods of the HASL diet sampling program along with a summary of the results obtained during the first 3 years of operation (1960–1963) was published earlier (*2*).

Starting in 1968, two changes have been made in the program because previous experience had shown the levels of strontium–90 in the Chicago diet to be consistently between those of New York City and San Francisco. Thus, reasonable estimates of the dietary intake of strontium–90 in Chicago at any time can be made from the analyses of foods purchased in New York City and San Francisco.

The second change, revision of the estimates of the annual consumption of different diet components, was made because new information became available. This new information on the composition of the diet appeared in a preliminary report of the U.S. Department of Agriculture in their 1965 Household Diet Survey (*3*). The changes in the composition of the diet from 1955 to 1965 are not very great, and the estimates of strontium–90 intake made using statistics from either diet survey are not too different. Estimates of the intakes of other nuclides, however, may be effected to a greater degree. The new estimates of the consumption have therefore been used to calculate the intakes of calcium and strontium–90 for the third and fourth quarters of 1968 in New York City and San Francisco.

Results of the August–September 1968 samplings are presented in table 1; November–December 1968 in table 2. The variation with time of the daily intake of strontium–90 in the three cities is plotted in figure 1.

[1] Data from Fallout Program Quarterly Summary Report, HASL 204, 207. Available from the Clearinghouse for Federal Scientific & Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet, August–September 1968

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City August 1968		San Francisco September 1968	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Dairy products	200	216.0	10.4	2,080	1.7	340
Fresh fruit	59	9.4	18.2	1,074	1.4	83
Fresh vegetables	48	18.7	12.2	586	4.4	211
Root vegetables	10	3.8	4.9	49	4.5	45
Potatoes	38	3.8	9.5	361	1.5	57
Macaroni	3	0.6	4.7	14	2.7	8
Rice	3	1.1	2.3	7	9.7	29
Fruit juices	28	2.5	3.3	92	1.1	31
Canned vegetables	22	4.4	9.3	205	1.9	42
Canned fruit	11	0.6	2.4	26	1.7	19
Dried beans	3	2.1	3.6	11	5.4	16
Flour	34	6.5	6.9	235	3.4	116
Bakery products	44	53.7	5.4	238	4.7	207
Whole grain products	11	10.3	8.5	94	6.3	69
Fresh fish	8	7.6	0.5	4	0.0	0
Shell fish	1	1.6	1.4	1	0.3	0
Poultry	20	6.0	2.4	48	1.1	22
Meat	79	12.6	10.0	79	0.7	55
Eggs	15	8.7	3.4	51	1.5	23
Annual intake		370.0		5,255		1,373
Daily intake (pCi/day)				14.3		3.8

Table 2. Average dietary consumption and strontim-90 intake in Tri-City diet, November–December 1968

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City November 1968		San Francisco December 1968	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Dairy products	200	216.0	10.8	2,160	2.1	420
Fresh fruit	59	9.4	18.0	1,062	4.7	227
Fresh vegetables	48	18.7	17.5	840	2.1	101
Root vegetables	10	3.8	7.9	79	4.8	48
Potatoes	38	3.8	.7	27	5.3	201
Macaroni	3	.6	3.6	11	2.9	9
Rice	3	1.1	8.9	27	1.4	4
Fruit juices	28	2.5	3.0	84	3.8	106
Canned vegetables	22	4.4	9.9	218	1.9	42
Canned fruit	11	.6	1.5	17	.7	8
Dried beans	3	2.1	1.7	5	10.8	32
Flour	34	6.5	6.6	224	3.4	116
Bakery products	44	53.7	6.4	282	4.2	185
Whole grain products	11	10.3	13.6	150	6.0	66
Fresh fish	8	7.6	.4	3	.6	5
Shell fish	1	1.6	1.2	1	1.8	2
Poultry	20	6.0	1.2	24	1.5	30
Meat	79	12.6	1.5	119	.5	40
Eggs	15	8.7	2.1	32	1.7	26
Annual intake		370.0		5,365		1,718
Daily intake (pCi/day)				14.7		4.7

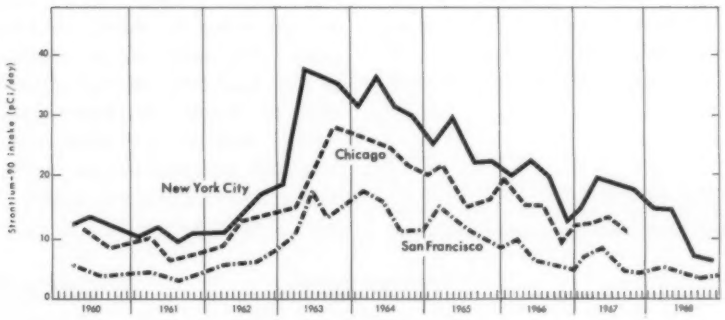

Figure 1. Daily intake of strontium-90 in Tri-City diet March 1960–December 1968

REFERENCES

(*1*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1, (1955). Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (December 1956).

(*2*) RIVERA, J., and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL–137. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964).

(*3*) U.S. DEPARTMENT OF AGRICULTURE. Food Consumption of Households in the United States, Spring 1965. A Preliminary Report, U.S.D.A., ARS 62–16 (August 1967.)

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
April–December 1967	June 1968
January–June 1968	April 1969

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90 respectively.

Water sampling program	Period reported	Issue
Colorado River Basin	1967	December 1968
Drinking Water Analysis Program	1961–1966	August 1968
Florida	1967	February 1969
Kansas	July–December 1967	November 1968
Minnesota	July–December 1968	November 1969
New York	July–December 1968	September 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, HASL	July–December 1968	November 1969
Washington	July 1967–June 1968	June 1969

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Wahington, D.C. 20402 (September 1961).

Radioactivity in California Waters,[1] January-June 1968

Bureau of Radiological Health, State of California Department of Public Health

Gross beta radioactivity in California domestic waters is monitored by the State of California's Bureau of Radiological Health. The importance of this program in the State's environmental surveillance activities stems from the fact that most of California's domestic water supplies are of surface origin.

[1] Data from July and October 1968 issues of Radiological Health News, State of California, Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley, Calif. 94704.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters and well waters. It should be noted that except for large metropolitan water supplies, raw water sampling is being phased out and treated water sampling being substituted or continued. This

Figure 1. California surface water sampling stations

procedural change is predicated upon sampling water at the point of consumption.

Most of the supplies sampled have, as a source, raw surface waters (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or surface streams. Under the present sampling schedule, monthly 500 ml samples are collected and the total solids analyzed for alpha and beta radioactivity. In addition, 3-liter samples are collected monthly for approximately 6 months and composited for specific radionuclide analysis on a semiannual basis.

Analytical procedures

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Labora-

Table 1. Gross beta radioactivity in California domestic waters January–June 1968

Sampling station	Quality	Concentration (pCi/liter)					
		January	February	March	April	May	June
Alturas	Well	▪12	▪33	NS	NS	ND	▪20
Antioch	Treated	ND	▪2	ND	ND	▪6	14
Berkeley	Treated	ND	ND	▪5	▪5	ND	▪12
Clearlake Highlands	Treated	▪5	ND	▪10	▪6	▪8	▪11
Crescent City	Well	ND	▪4	▪15	ND	ND	▪3
Death Valley	Treated	▪19	▪7	▪6	ND	▪4	▪13
Dos Palos	Treated	▪7	ND	▪22	▪8	ND	ND
Eureka	Raw	ND	▪2	▪20	▪10	▪19	▪11
	Treated	ND	ND	ND	▪11	ND	▪3
Fort Bragg	Treated	ND	▪18	ND	NS	NS	▪12
Lake Arrowhead	Treated	ND	▪11	▪9	▪7	NS	▪21
Lake Millerton	Raw	▪5	ND	ND	▪2	▪2	▪5
Los Angeles Laboratory	Raw	▪7	▪8	▪9	NS	NS	ND
Marin Municipal Water District	Treated	NS	NS	NS	▪10	ND	ND
Mariposa	Treated	NS	NS	NS	ND	ND	▪1
Metropolitan Water District of Southern California:							
Weymouth Plant	Treated	▪7	▪33	NS	31	40	54
Monterey	Treated	48	ND	ND	▪8	▪9	▪5
Napa	Treated	ND	ND	▪7	▪2	▪9	▪11
Needles	Well	ND	▪6	▪27	▪4	61	▪4
North Marin Water District	Treated	ND	▪12	▪5	ND	▪35	▪8
	Raw	116	▪25	ND	▪12	▪11	▪7
	Sludge[b]	45	▪17	40	▪42	▪20	ND
Oroville:							
Wyandotte Irrigation District	Treated	▪8	NS	▪13	▪22	ND	▪2
Pleasanton	Well	ND	ND	ND	▪8	▪4	ND
Redding	Treated	NS	NS	NS	NS	NS	▪6
Sacramento:							
American River	Treated	NS	NS	▪10	▪2	ND	▪36
Sacramento River	Treated	NS	NS	▪2	▪12	▪4	3
San Diego	Raw	▪7	▪2	▪5	▪17	▪16	▪12
	Treated	87	▪18	▪3	▪16	▪14	54
San Francisco:							
Water Department	Raw	ND	ND	ND	▪11	▪16	▪1
Alameda East	Raw	ND	▪1	▪9	▪2	ND	▪3
Brightside Weir	Raw	ND	ND	▪5	ND	▪4	ND
Calaveras Reservoir	Raw	8	ND	▪7	ND	▪2	▪5
Crystal Springs	Raw	▪2	▪6	▪14	ND	▪14	ND
Hetch Hetchy	Raw	▪9	▪2	▪22	▪5	▪13	ND
San Jose	Raw	ND	ND	▪4	ND	ND	▪2
San Luis Obispo	Treated	ND	ND	NS	NS	NS	NS
Santa Barbara	Treated	▪26	▪1	ND	ND	ND	▪4
Santa Cruz	Raw	ND	▪3	ND	ND	▪11	ND
	Treated	113	NS	NS	NS	NS	NS
Santa Rosa	Raw	ND	ND	NS	ND	▪3	▪2
	Well	▪4	ND	ND	NS	NS	NS
Scotia	Raw	▪5	3	▪15	▪3	▪6	▪7
	Treated	▪32	ND	ND	▪1	▪9	ND
Ukiah	Well	92	ND	▪16	ND	▪12	▪1
Vallejo:							
Fleming Hill	Raw	▪6	▪10	▪17	▪15	▪18	▪8
	Treated	▪2	ND	▪1	▪4	▪11	▪7
Swanzy Reservoir	Treated	▪23	▪2	▪14	▪22	NS	NS
Willits	Treated	▪11	▪3	ND	▪6	ND	ND
Yosemite	Treated	ND	▪5	▪2	▪12	▪21	▪7
Maximum		116	33	40	42	40	54
Minimum		2	1	1	1	2	1

▪ When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best estimate, but is not statistically significant.
[b] Sludge reported in pCi/g (dry weight).
NS, no sample collected.
ND, no detectable activity.

tory. Measurements of alpha and alpha-plus-beta radioactivities are made with a low-background windowless gas-flow proportional counter. Counting methods used follow those recommended by the U.S. Public Health Service (*1*).

Individual samples are evaporated to dryness and the residue ashed at 450°C. The ashed sample is dissolved and transferred to an aluminum planchet for beta-particle counting. Specific radionuclides are determined semiannually on composite samples. Gamma-ray emitting nuclides are determined by gamma-ray spectroscopy and radium and radiostrontium by chemical separation and counting.

Discussion

Table 1 shows the monthly average beta radioactivity in the suspended-plus-dissolved solids in surface water supplies in California from January through June 1968. Following treatment, these waters are used for industrial and domestic purposes. Because alpha radioactivity in water has, in general, been undetectable or very slight, alpha radioactivity analyses are not presented. No increase in radioactivity level of surface water has been observed.

REFERENCE

(*1*) U.S. PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analyses of environmental samples, R 59-6. Radiological Health Research activities, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (November 16, 1959).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	June 1968
July–December 1967	November 1968

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
Fallout in the United States and Other Areas, HASL	January–June 1968	October 1969
Plutonium in Airborne Particulates and Precipitation	April–June 1968	October 1969

1. Radiation Alert Network August 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during August 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, August 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Number of samples	Precipitation			
								Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	21	6	0	2	Dec 69	6	129	6	129	71
Alaska:	Adak	15	1	1	1	Dec 69	[c]				
	Anchorage	8	0	0	0	Aug 69	[c]				
	Attu Island	24	0	0	0	Mar 69	[c]				
	Fairbanks	[b]				Sept 69	[c]				
	Juneau	21	9	0	2	Oct 69	15	209	15	209	0
	Kodiak	[b]				Nov 69					
	Nome	[b]				May 69	[c]				
	Point Barrow	31	1	0	0	Apr 69	[c]				
	St. Paul Island	11	1	1	1	June 69	[c]				
Ariz:	Phoenix	15	7	1	4	Oct 69	[c]				
Ark:	Little Rock	5	7	3	5	Aug 69	[c]				
Calif:	Berkeley	21	1	0	0	Nov 69	[c]				
	Los Angeles	21	2	0	1	May 69	[c]				
C.Z:	Ancon	17	0	0	0	Nov 69	[c]				
Colo:	Denver	19	6	1	4	Nov 69	[c]				
Conn:	Hartford	20	1	0	1	Sept 69	5	47	5	47	0
Del:	Dover	21	5	0	1	July 69	[c]				
D.C:	Washington	29	2	0	1	Apr 69	5	170	5	170	42
Fla:	Jacksonville	21	1	0	0	Aug 69	7	156	7	156	56
	Miami	14	0	0	0	Sept 69	1	5	1	5	0
Ga:	Atlanta	21	4	0	2	June 69	2	79	2	79	50
Guam:	Agana	[b]				July 69	[c]				
Hawaii:	Honolulu	27	1	0	0	Mar 69	[c]				
Idaho:	Boise	21	3	1	2	Mar 69	[c]				
Ill:	Springfield	21	4	1	2	Apr 69	[c]				
Ind:	Indianapolis	11	3	1	2	June 69	2	56	2	56	2
Iowa	Iowa City	16	5	1	2	Nov 69	1	34	1	34	0
Kans:	Topeka	20	7	1	4	Aug 69	3	20	3	20	2
Ky:	Frankfort	9	6	1	3	Apr 69	[c]				
La:	New Orleans	19	1	0	0	Apr 69	9	211	[d]		
Maine:	Augusta	9	2	1	1	Oct 69	1	15	1	15	0
Md:	Baltimore	21	2	0	1	Sept 69	4	33	4	33	40
	Rockville	12	2	0	1	Mar 69	[c]				
Mass:	Lawrence	20	3	0	1	Nov 69	3	33	3	33	0
	Winchester	18	3	0	1	Dec 69	4	49	4	49	0
Mich:	Lansing	19	3	1	2	Mar 69	3	6	3	6	1
Minn:	Minneapolis	20	4	1	2	July 69	2	14	2	14	5
Miss:	Jackson	15	3	0	1	Oct 69	2	77	2	77	0
Mo:	Jefferson City	20	10	2	3	June 69	2	22	2	22	1
Mont:	Helena	21	3	1	2	Dec 69	1	74	1	74	0
Nebr:	Lincoln	15	9	3	6	June 69	2	29	2	29	0
Nev:	Las Vegas	13	2	0	1	Sept 69	[c]				
N.H:	Concord	20	2	1	1	Apr 69	[c]				
N.J:	Trenton	19	2	0	1	Oct 69	6	82	6	82	12
N.Mex:	Santa Fe	9	2	1	1	Dec 69	6	56	6	56	13
N.Y:	Albany	[b]				June 69	[c]				
	Buffalo	21	3	0	1	Nov 69	[c]				
	New York City	19	1	0	1	Dec 69	[c]				
N.C:	Gastonia	16	0	0	0	Nov 69	1	2	[d]		
N.Dak:	Bismarck	21	4	1	3	Apr 69	3	15	3	15	2
Ohio:	Cincinnati	[b]				July 69	[c]				
	Columbus	14	4	0	2	Oct 69	3	70	[c]		
	Painesville	21	4	1	3	Sept 69	3	16	3	16	2
Okla:	Oklahoma City	17	4	0	2	Mar 69	4	44	4	44	2
	Ponca City	21	6	0	2	Sept 69	4	44	4	44	0
Ore:	Portland	18	3	0	1	June 69	1	10	1	10	2
Pa:	Harrisburg	16	2	0	1	June 69	[c]				
P.R:	San Juan	[b]				Oct 69	[c]				
R.I:	Providence	20	6	0	3	Mar 69	6	85	6	85	9
S.C:	Columbia	18	4	0	2	Dec 69	3	49	3	49	17
S.Dak:	Pierre	11	6	1	4	Oct 69	[c]				
Tenn:	Nashville	20	3	0	2	Mar 69	4	83	4	83	0
Tex:	Austin	15	8	2	4	July 69	1	25	[d]		
	El Paso	[b]				Apr 69	[c]				
Utah:	Salt Lake City	30	3	1	2	May 69	4	6	4	6	0
Vt:	Barre	16	5	2	2	Aug 69	8	93	8	93	105
Va:	Richmond	21	2	0	1	Aug 69	4	125	4	125	15
Wash:	Seattle	9	1	0	0	Aug 69	2	3	[d]		
	Spokane	8	2	1	1	July 69	[c]				
W.Va:	Charleston	21	5	0	2	Dec 69	5	150	5	150	19
Wisc:	Madison	20	3	1	1	Aug 69	3	33	3	33	3
Wyo:	Cheyenne	20	6	1	3	Sept 69	1	5	1	5	1
Network summary		1,163	10	0	2		8	61	4	60	

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

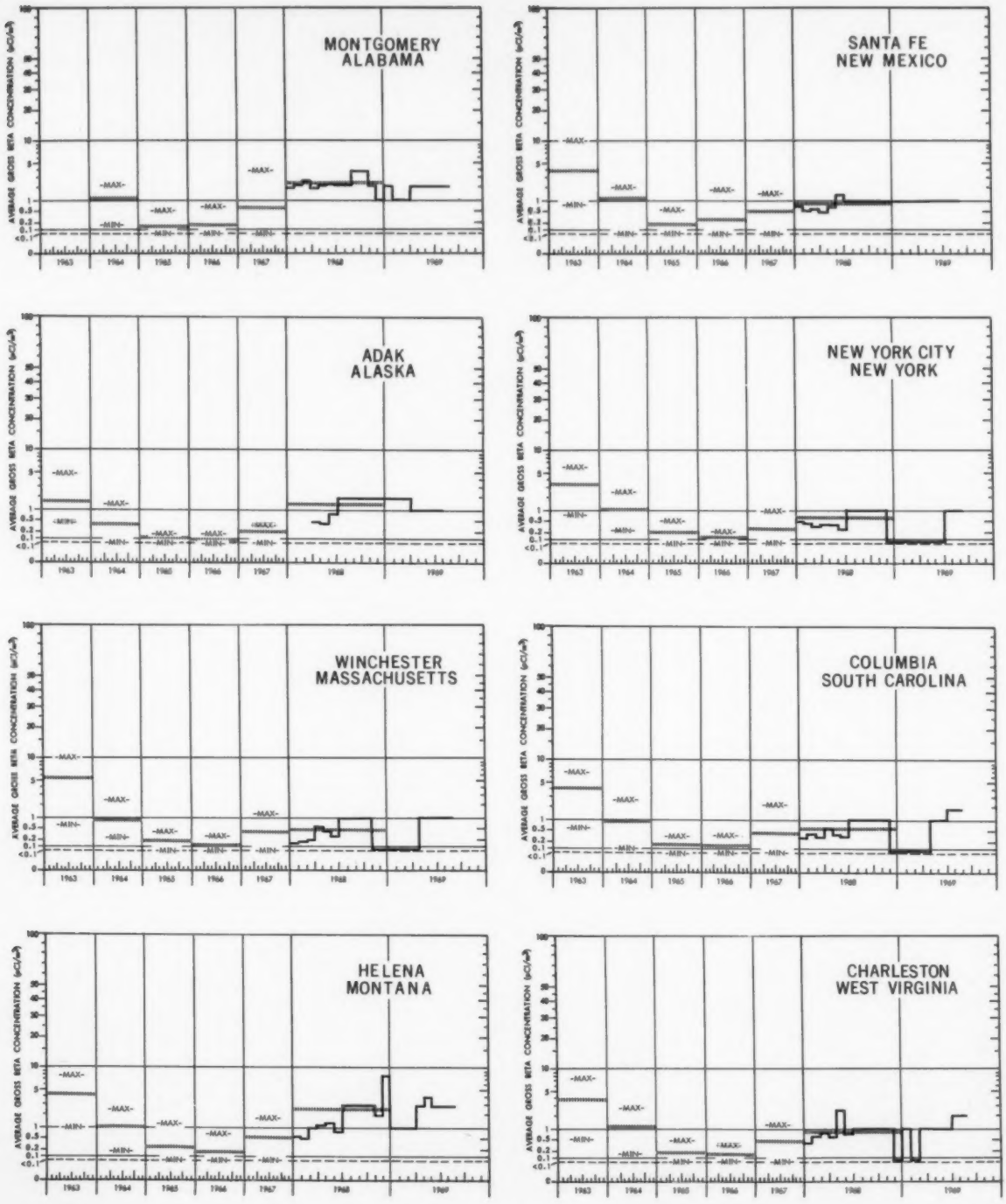

Figure 2. Monthly and yearly profiles of beta radioactivity in air, Radiation Alert Network, 1963–August 1969

2. Canadian Air and Precipitation Monitoring Program[1], August 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data in the September 1969 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for August 1969 are presented in table 2.

Table 2. Canadian gross beta radioacivity in surface air and precipitation, August 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.4	0.1	0.2	141	2.2
Coral Harbour	29	.3	.0	.2	NS	NS
Edmonton	31	.6	.1	.3	111	13.7
Ft. Churchill	29	.5	.0	.2	96	10.0
Ft. William	7	.4	.2	.3	211	11.4
Fredericton	31	.4	.1	.2	51	3.7
Goose Bay	31	.3	.0	.1	30	4.5
Halifax	30	.4	.0	.2	63	2.8
Inuvik	31	.2	.0	.0	39	6.3
Montreal	30	.6	.1	.4	22	1.9
Moosonee	31	.6	.0	.3	76	7.5
Ottawa	31	.6	.1	.3	90	6.6
Quebec	31	.5	.0	.2	106	12.2
Regina	31	.6	.1	.3	226	10.8
Resolute	31	.3	.0	.1	52	2.1
St. John's, Nfld.	31	.3	.0	.2	27	5.8
Saskatoon	30	.5	.1	.3	396	4.6
Saulte Ste Marie	31	.5	.2	.4	102	8.0
Toronto	31	.7	.2	.4	149	4.1
Vancouver	31	.3	.0	.2	79	3.9
Whitehorse	31	.3	.0	.2	86	5.4
Windsor	30	.5	.1	.3	55	6.1
Winnipeg	31	.6	.1	.3	147	8.4
Yellowknife	28	.3	.0	.1	44	6.2
Network summary	682	0.7	0.0	0.2	104	6.4

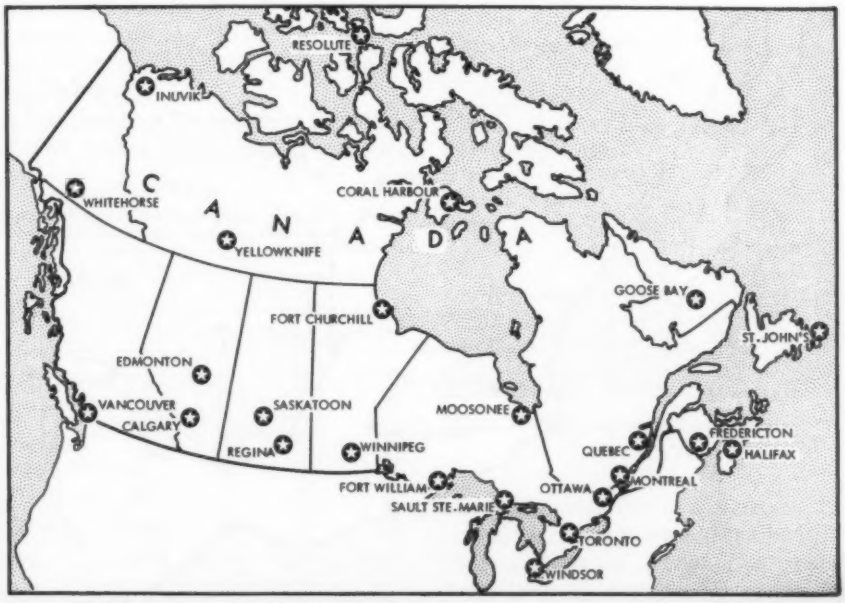

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program January and February 1969

National Commission of Nuclear Energy
México, D. F.

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energia Nuclear (CNEN), México, D. F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D. F.; Mérida; Veracruz; San Luis Potosí and Ensenada. Staff members of the DRS operate the station at México, D. F., while the other four stations are manned by members of the Centro de Prevision del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6 by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Secciónde Radioactividad Ambiental, CNEN, in México, D. F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of randon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (*1*).

The maximum, minimum, and average beta radioactivity in surface air during January and February 1969 are presented in tables 3 and 4.

Figure 4. Mexican air sampling stations

Table 3. Mexican gross beta radioactivity of airborne particulates January 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	N8			
Chihuahua	3	0.1	<0.1	
Ciudad Juarez	N8			
Ensenada	5	.4	.1	0.2
Guadalajara	N8			
Guaymas	N8			
La Paz	N8			
Matamoros	N8			
Mazatlan	N8			
Mérida	N8			
México, D.F.	2	.2	< .1	
Nuevo Laredo	6	.3	.1	.2
San Luis Potosí	N8			
Tampico	N8			
Torreon	6	.3	.1	.2
Veracruz	1	.1	.1	

N8, no sample, station temporarily shutdown.

Table 4. Mexican gross beta radioactivity of airborne particulates February 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	14	0.2	0.1	0.1
Chihuahua	3	.3	.2	.2
Ciudad Juarez	4	.2	.1	.1
Ensenada	1	.1	.1	
Guadalajara	N8			
Guaymas	N8			
La Paz	N8			
Matamoros	N8			
Mazatlan	8	.4	.1	.3
Mérida	15	.2	.1	.1
México, D.F.	2	.2	.1	
Nuevo Laredo	N8			
San Luis Potosí	N8			
Tampico	N8			
Torreon	N8			
Veracruz	14	.2	<.1	.1

N8, no sample, station temporarily shutdown.

3. Pan American Air Sampling Program August 1969

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 5. It should be noted that a new sampling station has been established in Cuenca, Ecuador. Analytical techniques were described in the January 1968 *Radiological Health Data and Reports*. The June 1969 air monitoring results from the participating countries are given in table 5.

Figure 5. Pan American Air Sampling Program stations

Table 5. Summary of gross beta radioactivity in Pan American surface air, August 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	17	0.35	0.00	0.07
Bolivia:	La Paz	4	.26	.07	.10
Chile:	Santiago	31	.27	.02	.14
Colombia:	Bogota	17	.02	.00	.01
Ecuador:	Cuenca	17	.06	.01	.02
	Guayaquil	10	.13	.04	.07
	Quito	16	.01	.00	.00
Guyana:	Georgetown	14	.07	.00	.04
Jamaica:	Kingston	16	.30	.03	.17
Peru:	Lima	6	.15	.06	.10
Venezuela:	Caracas	16	.29	.01	.05
West Indies:	Trinidad	19	.23	.01	.06
Pan American summary		183	0.35	0.00	0.07

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963–1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiologica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Alpha Radioactivity in Colorado Uranium Mines 1961-1968

Colorado Bureau of Mines[1]

The Colorado Bureau of Mines with the cooperation of the mine operators has been inspecting underground uranium mines for concentrations of radon daughters since 1961. Using a portable air sampler, a 10 to 15-liter sample of air is taken at each of several positions in the mine. After allowing the filter to decay for 40 to 90 minutes, the alpha radioactivity is measured with an alpha survey meter. Applying the appropriate correction and calibration factors, the counts per minute from the survey meter are converted into working levels.[2] Table 1 presents a comparison of levels of alpha radioactivity in terms of working levels found in operating uranium mines for the years 1961 through 1968. During this period, the percentage of mines containing alpha radioactivity concentrations of 3.0 working levels or less increased from 72.5 to 98.7 percent.

Results of mines inspections for January–December 1968 are presented in table 2.

[1] Taken from "A Summary of Mineral Industry Activities in Colorado, 1967" Colorado Bureau of Mines and personal correspondence with the Colorado Bureau of Mines.

[2] One "working level" is defined as any combination of radon daughters in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha-particle energy. The numerical value of the working level is derived from the alpha-particle energy released by the total decay of the short-lived radon daughter products at radioactive equilibrium with 100 pCi of radon-222 per liter of air.

Table 1. Results of mine inspections in Colorado, 1961–1968

Average working level (WL) range	Percent of mines in range							
	1961	1962	1963	1964	1965	1966	1967	1968
≤ 1.0 WL	45	52	40.5	43	52	60	67	83.92
> 1.0 WL – 3.0 WL	27.5	38	47	41	41.25	34.5	27.5	14.82
> 3.0 WL – 5.0 WL	23	10	12.5	16	6	5.5	4.75	.42
> 5.0 WL – 10.0 WL					.75		.5	.63
>10.0 WL	4.5						.25	.21
Total	100	100	100	100	100	100	100	100

Table 2. Results of mine inspections in Colorado, January–December 1968

Average working level (WL) range	January–March 1968			April–June 1968			July–September 1968			October–December 1968		
	Number of mines	Percent of mines in range	Cumulative percent of mines	Number of mines	Percent of mines in range	Cumulative percent of mines	Number of mines	Percent of mines in range	Cumulative percent of mines	Number of mines	Percent of mines in range	Cumulative percent of mines
≤ 1.0 WL	104	80.62	80.62	100	85.47	85.47	95	79.83	79.83	103	90.35	90.35
> 1.0 WL – 3.0 WL	23	17.83	98.45	15	12.82	98.29	22	18.49	98.32	11	9.65	100.00
> 3.0 WL – 5.0 WL	1	.78	99.23	1	.86	99.15	0	0	98.32	0		
> 5.0 WL – 10.0 WL	1	.77	100.00	1	.85	100.00	1	.84	99.16	0		
>10.0 WL	0	0	100.00	0	0	100.00	1	.84	100.00	0		
Total	129			117			119			114	100.00	

Strontium-90 in Human Bone, October-December 1968[1]

Bureau of Radiological Health
U.S. Public Health Service

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older age groups have shown their bone strontium–90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained postmortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

[1] Period during which death or surgical procedure occurred.

Laboratory procedures

The bones are analyzed at Northeastern Radiological Health Laboratory of the Bureau of Radiological Health at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium–90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium–90 content is then calculated (*3*) from the yttrium–90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium–90) are analyzed periodically and cross-check analyses are carried out quarterly with the Health and Safety Laboratory of the AEC, which performs similar analyses.

The analytical results for strontium–90 in individual bones from persons dying during the fourth quarter (October–December) of 1968 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are

Figure 1. Geographical regions for human bone sampling

Table 1. Strontium-90 in human bone, October–December 1968

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	$^{90}Sr/Ca$ (pCi/g)
Northeast: N.Y.	V	3	F	87.0 ± 9.3	34.5	2.52
	V	4	M	119.0 ± 8.7	27.6	4.31
	V	5	F	57.4 ± 5.5	21.3	2.69
Pa.	V	6	M	84.5 ± 8.7	30.9	2.73
N.Y.	V	6	F	130.0 ± 11.0	38.8	3.35
Vt.	V	7	M	82.3 ± 9.3	33.8	2.43
N.Y.	V	7	M	131.0 ± 12.0	53.7	2.43
Pa.	V	9	F	86.1 ± 8.0	41.4	2.07
Mass.	V	10	M	70.9 ± 6.4	35.7	1.98
	V	11	M	97.7 ± 10.0	34.8	2.80
Vt.	V	12	M	78.8 ± 9.5	34.2	2.30
N.Y.	V	12	F	62.9 ± 7.0	32.4	1.94
N.J.	V	13	F	134.0 ± 9.5	43.6	3.07
N.Y.	V	13	M	46.1 ± 6.2	26.5	1.73
	V	14	M	83.1 ± 10.0	39.2	2.11
	V	14	M	74.7 ± 10.0	42.2	1.77
	V	15	F	74.2 ± 7.7	43.7	1.69
Conn.	V, R	16	M	99.4 ± 7.9	42.9	2.31
N.Y.	V	17	F	128.0 ± 9.7	48.8	2.62
Mass.	V	18	M	127.0 ± 16.0	58.3	2.17
Vt.	V	19	M	145.0 ± 10.0	58.2	2.49
N.J.	V	19	M	102.0 ± 11.0	45.4	2.24
	V	20	M	98.1 ± 9.0	34.6	2.83
Pa.	V	20	M	85.2 ± 10.0	51.6	1.65
Mass.	V	21	M	133.0 ± 13.0	45.3	2.93
Vt.	V	21	M	74.1 ± 9.9	51.3	1.44
	V	21	M	162.0 ± 15.0	63.0	2.57
N.J.	V	21	M	132.0 ± 10.0	68.6	1.92
Southeast: N.C.	V	2	F	101.0 ± 10.0	32.3	3.12
N.Y.	V	5	F	49.5 ± 5.2	22.9	2.16
S.C.	V	5	M	98.8 ± 9.5	30.0	3.29
Md.	V	13	M	90.0 ± 10.0	41.7	2.15
S.C.	V	13	F	188.0 ± 14.0	52.4	3.58
	V	14	F	98.8 ± 8.3	33.2	2.97
Md.	V	15	F	138.0 ± 13.0	71.4	1.93
	V	15	F	184.0 ± 15.0	70.2	2.62
	V	16	M	176.0 ± 13.0	66.7	2.63
	V	17	M	107.0 ± 10.0	54.0	1.98
Ga.	V	17	M	145.0 ± 9.9	59.9	2.42
Md.	V	18	M	188.0 ± 15.0	61.4	3.06
	V	18	M	293.0 ± 14.0	53.1	5.51
	V	18	M	140.0 ± 11.0	61.5	2.27
	V	19	F	146.0 ± 15.0	53.3	2.73
	V	19	M	135.0 ± 12.0	74.2	1.81
	V	20	F	117.0 ± 10.0	53.5	2.18
	V	20	M	101.0 ± 8.3	46.6	2.16
	V	20	M	119.0 ± 9.6	58.9	2.02
S.C.	V	20	M	99.0 ± 8.0	39.1	2.53
Ga.	V	20	M	84.3 ± 8.3	51.9	1.62
Md.	V	21	M	94.3 ± 10.0	50.0	1.88
	V	21	M	108.0 ± 11.0	49.5	2.18
W. Va.	V	22	F	61.0 ± 7.2	37.8	1.61
Md.	V	22	M	183.0 ± 16.0	63.4	2.88
	V	22	M	101.0 ± 12.0	74.8	1.35
	V	22	F	103.0 ± 9.2	50.6	2.03
	V	22	M	140.0 ± 12.0	59.3	2.36
	V	24	M	77.1 ± 7.8	50.2	1.53
	V	24	M	106.0 ± 11.0	52.8	2.00
S.C.	V	24	F	95.1 ± 10.0	49.4	1.92
Md.	V	25	M	124.0 ± 10.0	54.1	2.29
Central: Wisc.	V	1	M	59.3 ± 7.2	29.5	2.01
Ohio	V	2	M	127.0 ± 11.0	45.0	2.82
Wisc.	V	4	F	61.9 ± 7.5	31.0	1.99
	V	4	M	134.0 ± 9.2	18.0	7.44
	V	4	F	52.1 ± 6.1	28.5	1.82
	V	8	M	40.7 ± 5.2	22.1	1.84
	V	8	F	89.9 ± 9.4	36.9	2.43
	V	8	M	46.5 ± 5.5	22.4	2.07
Ohio	V	12	M	103.0 ± 8.6	35.5	2.90
	V	15	M	120.0 ± 9.8	66.4	1.80
Mich.	V	15	M	85.6 ± 8.2	49.9	1.71
Ohio	V	16	M	94.0 ± 11.0	58.3	1.61
	V	16	M	165.0 ± 16.0	67.4	2.44
	V	17	M	120.0 ± 13.0	88.5	1.35
	V	18	M	206.0 ± 15.0	76.8	2.68
	V	18	M	186.0 ± 17.0	90.7	2.05
	V	21	M	111.0 ± 12.0	74.6	1.48
	V	23	M	200.0 ± 16.0	76.4	2.61
Northwest: Ore.	V	1	M	51.1 ± 7.1	26.3	1.94
	V	1	M	65.2 ± 7.6	27.0	2.41
	V	1	M	99.3 ± 9.2	32.1	3.09
	V	4	M	106.0 ± 10.0	32.9	3.22
	V	11	M	86.2 ± 7.5	30.7	2.80
Wash.	V	16	M	125.0 ± 9.6	48.3	2.58
Ore.	LB	18	M	296.0 ± 13.0	175.0	1.69
	V	18	M	94.3 ± 9.3	46.6	2.02
	V	18	M	153.0 ± 11.0	52.2	2.93
	V	19	M	71.0 ± 8.9	44.5	1.59

See footnotes at end of table.

Table 1. Strontium-90 in human bone, October–December 1968—Continued

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] pCi/kg bone)	Calcium concentration (g/kg bone)	$^{90}Sr/Ca$ (pCi/g)
Northwest: Ore	V	20	F	112.0 ± 13.0	58.0	1.93
	LB	20	M	436.0 ± 23.0	224.0	1.79
	SK	21	F	402.0 ± 22.0	227.0	1.77
	V	22	M	149.0 ± 16.0	76.9	1.93
	V	23	M	69.4 ± 9.7	55.2	1.25
	V	25	F	72.8 ± 7.9	60.5	1.20
	V	25	F	85.9 ± 11.0	51.2	1.67
Southwest: Colo	V	15	F	62.6 ± 9.8	52.1	1.20
Hawaii	V	18	M	57.8 ± 7.6	46.7	1.23
Colo	V	19	F	63.3 ± 8.2	51.8	1.22
	V	19	M	76.1 ± 11.0	54.7	1.39
Calif	V	20	M	45.5 ± 7.2	45.3	1.00
Colo	V	22	F	67.3 ± 8.4	61.3	1.09
	V	24	F	100.0 ± 14.0	61.4	1.62
	V	24	M	113.0 ± 13.0	72.8	1.55
	V	24	M	78.3 ± 8.8	55.6	1.40
North: Alaska	R	18	M	382.0 ± 38.0	120.0	3.18
	R	18	F	200.0 ± 35.0	137.0	1.46
	R	19	M	332.0 ± 37.0	126.0	2.63
	R	23	F	189.0 ± 37.0	107.0	1.77

[a] Type of bone, V, vertebrae; R, rib; SK, skull; LB, long bone.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

given in picocuries of strontium–90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2-5*).

Recent coverage in *Radiological Health Data and Reports*

Period	Issue
October–December 1967	February 1969
January–March 1968	April 1969
April–June 1968	July 1969
July–September 1968	September 1969

REFERENCES

(*1*) RIVERA, J. Strontium–90 in human vertebrae, 1962–1963. Radiol Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium–90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64–1. Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium–90 in human bone, 1962–1963. Radiol Health Data 5:620–628 (December 1964).

(*5*) HALLISEY, R. M., and M. A. WALL. Strontium–90 in human bone, 1964–1965. Radiol Health Data Rep 8:415–419 August 1967).

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installatons. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Mound Laboratory and the Neutron Devices Department (formerly known as Pinellas Peninsula Plant).

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Mound Laboratory[2] July–December 1968

Monsanto Research Corporation
Miamisburg, Ohio

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specified for the radionuclides which could be released to the environment. Only polonium–210, plutonium–238, and hydrogen–3 (tritium) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha-particle emitters was used in the routine monitoring of environmental air within a radius of 20 miles from the laboratory during the collection period. Since the sampling zone is dependent on the wind direction it is possible that air samples from all zones will not be collected during the reporting period.

Airborne polonium and plutonium particulates are collected with a high-volume air sampler. The filter papers are then processed such that counting results are specific for polonium and plutonium. One fourth of each filter paper is processed by spontaneous deposition to isolate polonium. The remaining three fourths of each filter paper is processed chemically to remove polonium. The remaining alpha radioactivity is interpreted as plutonium; however, some of this alpha radioactivity is probably due to naturally occurring alpha-particle emitters.

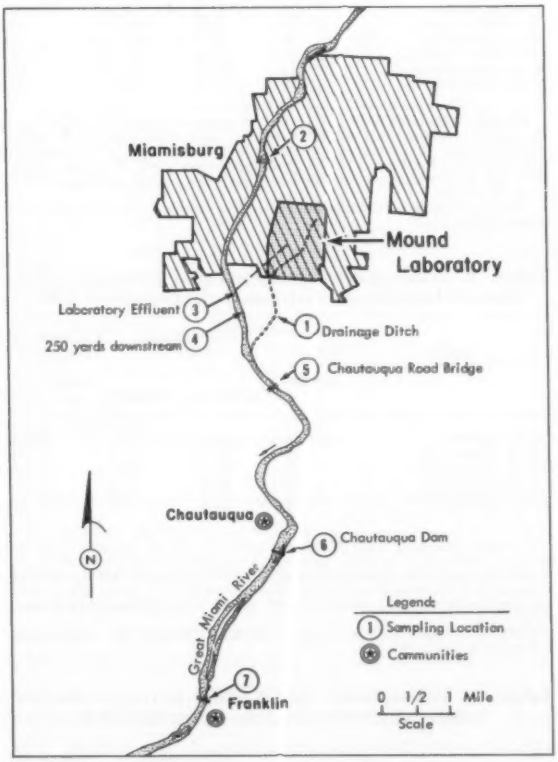

Figure 1. Water sampling locations, Mound Laboratory

Airborne tritium is monitored by bubbling air through a liquid scintillation counting solution

[2] Summarized from "Environmental Monitoring Report, July–December 1968" (MLM–1619).

with p-dioxane as the organic solvent. The counting solution is counted directly in a liquid spectrometer.

The results of the airborne monitoring program are presented in tables 1, 2 and 3. The average concentration of plutonium, polonium, and tritium in the environment are below the AEC radiation protection standards.

Table 1. Atmospheric monitoring of polonium-210, Mound Laboratory environs, July–December 1968

Range (miles)	Number of samples	Concentration (fCi/m^3)[a]		Average as percent of AEC standards[b]
		Maximum	Average	
0– 3 (upwind)	16	41.2	17.8	0.09
0– 3 (downwind)	16	57.0	19.7	.10
3– 5 (downwind)	16	36.7	21.0	.10
5–10 (downwind)	16	114.6	21.3	.11
10–15 (downwind)	16	100.2	28.0	.14
15–20 (downwind)	16	51.5	15.2	.08

[a] Lowest detectable level (LDL) for polonium–210 in air is 8.0 fCi/m^3 for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 5.3 fCi/m^3 for samples collected 0–3 miles downwind and 15–20 miles downwind. All vaules which were not detectable were set equal to these values when average values were calculated.

[b] The applicable AEC radiation protection standard for polonium–210 in air is 20 pCi/m^3.

Table 2. Atmospheric monitoring of plutonium-238, Mound Laboratory environs, July–December 1968

Range (miles)	Number of samples	Concentration (fCi/m^3)[a]		Average as percent of AEC standards[b]
		Maximum	Average	
0– 3 (upwind)	14	24.2	7.3	10.43
0– 3 (downwind)	14	27.6	6.3	9.00
3– 5 (downwind)	14	43.5	11.5	16.43
5–10 (downwind)	14	23.0	8.2	11.71
10–15 (downwind)	14	29.6	9.9	14.14
15–20 (downwind)	14	18.5	5.7	8.14

[a] Lowest detectable limit (LDL) for plutonium in air is 1.3 fCi/m^3 for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 0.9 fCi/m^3 for samples collected 0–3 downwind and 15–20 miles downwind. All values which were not detectable were set equal to these values when average values were calculated.

[b] The applicable AEC radiation protection standard for plutonium–238 in air is 70 fCi/m^3.

Table 3. Atmospheric monitoring tritium, Mound Laboratory environs, July–December 1968

Range (miles)	Number of samples	Concentration (nCi/m^3)[a]		Average as percent of AEC standards[b]
		Maximum	Average	
0– 3 (upwind)	17	2.63	2.11	1.05
0– 3 (downwind)	17	41.74	4.38	2.19
3– 5 (downwind)	17	3.34	2.17	1.08
5–10 (downwind)	17	2.33	2.02	1.01
10–15 (downwind)	17	3.10	2.07	1.03
15–20 (downwind)	17	2.53	2.04	1.02

[a] Lowest detectable limit for tritium in air is 2.00 nCi/m^3. All values which were not detectable were set equal to this value when average values were calculated.

[b] The applicable AEC radiation protection standard for tritium in air is 200 nCi/m^3.

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed separately to reduce the concentrations of these radionuclides to a level at which they may be discharged to the environment. Treated polonium liquid waste is discharged to the Great Miami River via a closed sewer line which also carries the treated plant sewage. The treated plutonium waste is discharged to a drainage ditch which runs through the plant site and eventually reaches the river.

Helium–3, which is purified at the Mound Laboratory, contains small quantities of tritium. In addition, tritium is recovered from various AEC tritium-contaminated wastes. Liquid waste generated by these operations is treated (diluted with water when necessary) and is discharged to the same closed sewer line as polonium. Some tritium-contaminated liquid wastes are discharged to the drainage ditch which runs through the site and eventually reaches the river.

Water samples are collected weekly from the Great Miami River, the drainage ditch and two ponds northeast of Mound Laboratory (figure 1). The average concentrations of plutonium and tritium in water discharged to the environment were well below the AEC radiation protection standards. The data indicate that the average concentration of polonium in the plant effluent water for the 6-month period, July–December 1968, was 1.7 times the AEC radiation protection standard. However, the average concentration of polonium in the effluent water for the 12-month period was 0.87 times the standard which meets the stringent water pollution standards of the AEC. The average concentration during the 6-month period, July–December, resulted from a break in buried waste lines which allowed polonium contaminated liquid waste to enter an adjacent sanitary line, thus by-passing the radioactive waste disposal facility. The lines were repaired, and the concentration of polonium in the effluent returned to normal. Average concentrations of tritium, polonium–210 and plutonium–238 are given in table 4 for July–December 1968.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1967	September 1968
January–June 1968	May 1969

Table 4. Offsite water monitoring for radioactivity, Mound Laboratory environs July–December 1968

Nuclide and sampling location[a]	Number of samples	Concentration	
		Maximum	Average[b]
Polonium–210[c] (pCi/liter)			
1 (Drainage ditch)	20	47.7	5.54
2 (Upstream from laboratory)	20	3.60	1.94
3 (Laboratory effluent)	20	8,016	1,202
4 (250-yards downstream)	20	50.4	8.9
5 (Chautauqua Road Bridge)	20	49.5	7.65
6 (Chautauqua Dam)	20	298	16.4
7 (Franklin, Ohio)	20	63.1	7.70
8 (Pond, opposite V.A. hospital, Dayton, Ohio, 8 mi. NE of Mound Laboratory)	20	1.8	1.8
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 mi. NE of Mound Laboratory)	20	3.60	1.94
Plutonium–238 (pCi/liter)			
1 (Drainage ditch)	18	254	60
2 (Upstream from laboratory)	18	8.11	5.41
3 (Laboratory effluent)	18	157	25.2
4 (250-yards downstream)	18	66.7	8.56
5 (Chautauqua Road Bridge)	18	27.9	6.31
6 (Chautauqua Dam)	18	14	6.31
7 (Franklin, Ohio)	18	10.8	5.86
8 (Pond, opposite V.A. Hospital, Dayton, Ohio, 8 mi NE of Mound Laboratory)	18	25.2	5.86
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 mi NE of Mound Laboratory)	18	9.46	4.95
Hydrogen–3 (tritium) (μCi/liter)			
1 (Drainage ditch)	20	7.76	1.10
2 (Upstream from Laboratory)	20	1.04	.10
3 (Laboratory effluent)	20	2.74	.25
4 (250-yards downstream)	20	.05	.06
5 (Chautauqua Road Bridge	20	.05	.05
6 (Chautaugua Dam)	20	.05	.05
7 (Franklin, Ohio)	20	.05	.05
8 (Pond, opposite V.A. Hospital, Dayton, Ohio, 8 mi. NE of Mound Lab)	20	.36	.07
9 (Pond, Possum Creek Reserve, Dayton, Ohio, 6 mi. NE of Mound Lab.)	20	.05	.05

[a] See figure 1 for number of sampling locations.
[b] The applicable AEC radiation protection standards for uncontrolled area are as follows:
Polonium–210 in water: 700 pCi/liter
Plutonium–238 in water: 5 nCi/liter.
Hydrogen–3 in water: 3 μCi/liter
[c] Minimum detectable level for polonium–210 in water is 1.80 pCi/liter.
Minimum detectable level for hydrogen–3 in water is 50 nCi/liter.
Minimum detectable level for plutonium–238 in water is 4.50 pCi/liter.
All samples which were not detectable were set equal to their respective minimum detectable level when average values were calculated.

2. Neutron Devices Department[3] January–June 1968

General Electric Company
St. Petersburg, Florida

The Neutron Devices Department, shown in figure 2, is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plants's contamination control measures. Effluent radioactivity concentrations and associated atmospheric and stream dilution factors indicate offsite radioactivity concentrations encountered by the general population are substantially lower than the guides for continuous non-occupational exposure established by AEC and documented in the "AEC Manual."

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily near the perimeter of the plant's property. During the sampling period 5 of 234 samples analyzed showed detectable concentrations of tritium (> 90 nCi/liter). The maximum concentration (480 nCi/liter, detected on March 8, 1968)

[3] Summarized from "Environmental Monitoring, January 1 through June 30, 1968" General Electric Company, Neutron Devices Department, St. Petersburg, Fla.

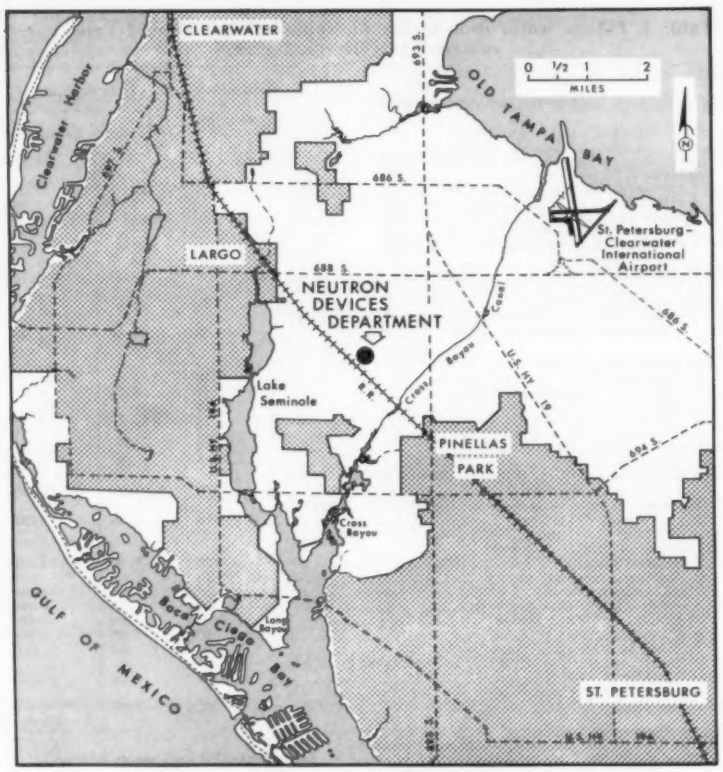

Figure 2. Location of the Neutron Devices Department

represented 16 percent of the continuous non-occupational exposure guide. Calculations based on radioactivity releases from the process waste system, and the plant's water discharges, indicate that the average tritium concentration in the combined sewer effluent for the first half of 1968 was less than 0.5 percent of the AEC radiation protection standard for continuous non-occupational exposure.

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium (>90 nCi/liter) in the 92 surface water samples analyzed during the sampling period.

Milk sampling results

Analyses of twelve raw milk samples, collected from one local dairy farm by the Pinellas County Health Department, revealed no detectable concentrations (>90 nCi/liter) of tritium.

Air sampling results

No detectable amounts of tritium gas (>20 μCi/m^3) or tritium oxide (>5.0 nCi/m^3) were found in two samples of air obtained downwind from the exhaust stack at the perimeter of the plant property.

Recent coverage in *Radiological Health Data and Reports*

Period	Issue
January–June 1967	February 1968
July–December 1967	May 1969

Reported Nuclear Detonations, November 1969

(Includes seismic signals from foreign test areas)

The U.S. Atomic Energy Commission announced that a nuclear test of low-intermediate yield (20 to 200 kilotons TNT equivalent) was conducted underground at its Nevada Test Site on November 21, 1969.

Announcement was also made by the U.S. Atomic Energy Commission that the United States recorded seismic signals on November 29, 1969, originating from the Soviet nuclear test area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the intermediate yield range.

Annual Subject Index

Radiological Health Data and Reports — Volume 10—1969

O

P, Q

R

S

T

U, V

W

X, Y, Z

Author Index

Radiological Health Data and Reports — Volume 10—1969

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

OFFSITE RADIOLOGICAL SURVEILLANCE FOR PROJECT GASBUGGY, JUNE 1967–JULY 1968. *John R. McBride and Dixon Hill. Radiological Health Data and Reports, Vol. 10, December 1969*, pp. 535–546.

Project Gasbuggy, an experiment to stimulate gas recovery by nuclear means, was conducted on December 10, 1967, as part of the Atomic Energy Commission's (AEC) Plowshare program. The Public Health Service by Memorandum of Understanding with the AEC is responsible for a comprehensive offsite radiological safety program. The data obtained during this program have documented that no radioactivity was introduced into the environment as a result of the Project Gasbuggy detonation. Surveillance of the El Paso natural gas producing wells near the Gasbuggy experiment was conducted to insure that gas contaminated with radioactivity was not present.

Keywords: Project Gasbuggy, offsite surveillance, natural gas, Plowshare, air, water, milk, external radiation.

ORDER BLANK FOR RHD&R

To: Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

Please enter my subscription for Radiological Health Data and Reports. I am enclosing Money Order ☐ Check☐ for this subscription. ($6.00 a year; $1.50 additional for foreign mailing.)

Please address RHD&R as follows._____

_____

_____

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C., 1969
For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Subscription price $6.00 a year, $1.50 additional for foreign mailing.
Price for a single copy of this issue is 50 cents.

December 1969

...notes
...health.
...data and
...subject
...author
...work.

...ations: Glossy photographic prints or original ... suitable for reproduction which help enunderstanding of the text should be included ... manuscript. Graphic materials should be of ... size so that lettering will be legible after ... printed page size (8½ by 6½ inches).

... illustrations should be numbered and each legend ... typed, double-spaced on a separate sheet of ... Legends should be brief and understandable ... reference to text. The following information ... typed on a gummed label or adhesive strip ... to the back of each illustration: figure ... legend, and title of manuscript or name of ...

... Tables should be self-explanatory and should ... not duplicate, the text. Each table should ... on a separate sheet, double-spaced. All tables ... numbered consecutively beginning with 1, and ... have a title.

... equations: All equations must be typewritten, preferably ... symbols which are defined immediately ... the equation. The definition of symbols should ... the units of each term. Special symbols, such ... letters, may be printed carefully in the proper ... Exponents and subscripts should be clearly ... Mathematical notations should be simple, ... when feasible such complexities as fractions ... fractions, subscripts with subscripts, etc.

Symbols and units: The use of internationally accepted units of measurements is preferred. A brief list of symbols and units commonly used in *Radiological Health Data and Reports* is given on the inside front cover of every issue and examples of most other matters of preferred usage may be found by examining recent issues. Isotope mass numbers are placed at the upper left of elements in long series or formulas, *e.g.*, ^{137}Cs; however, elements are spelled out in text and tables, with isotopes of the elements having a hyphen between element name and mass number; *e.g.*, strontium–90.

References: References should be typed on a separate sheet of paper.

Personal communications and unpublished data should not be included in the list of references. The following minimum data for each reference should be typed double-spaced: names of all authors in caps, complete title of article cited, name of journal abbreviated according to *Index Medicus*, volume number, first and last page numbers, month or week of issue, and year of publication. They should be arranged according to the order in which they are cited in the text, and not alphabetically. All references must be numbered consecutively.

Reprints

Contributors are ordinarily provided with 50 courtesy copies of the articles in the form of reprints. In cases of multiple authorship, additional copies will be provided for coauthors upon request.

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
WASHINGTON, D.C. 20201

OFFICIAL BUSINESS

If you do not desire to continue receiving this publication, please CHECK HERE
tear off this label and return it to the above address. Your name will be
promptly removed from the appropriate mailing list.